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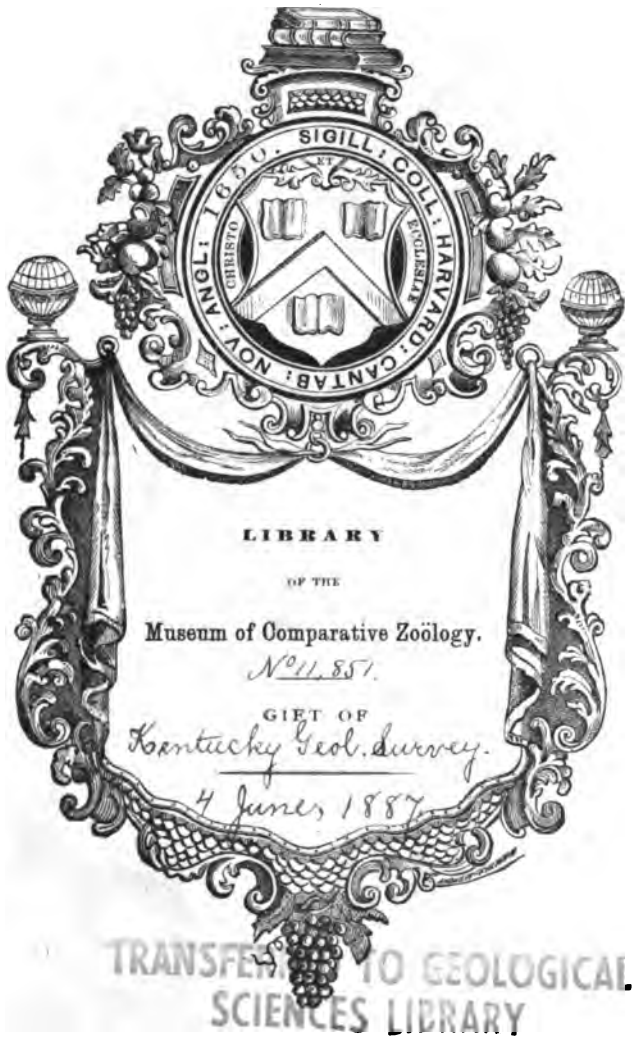

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GEOLOGICAL SURVEY OF KENTUCKY.

CHEMICAL ANALYSES.

A

Part I.

FIRST, SECOND, AND THIRD CHEMICAL REPORTS, AND CHEMICAL ANALYSES OF THE HEMP AND BUCKWHEAT PLANTS.

BY ROBERT PETER, M. D., ETC., ETC., CHEMIST TO THE SURVEY,
AND JOHN H. TALBOTT AND A. M. PETER, ASSISTANTS.

STEREOTYPED FOR THE SURVEY
BY MAJOR, JOHNSTON & BARRETT.
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1884.

CONTENTS.

PAGE.

FIRST CHEMICAL REPORT 1

SECOND CHEMICAL REPORT 181

THIRD CHEMICAL REPORT 347

CHEMICAL EXAMINATION OF THE HEMP AND BUCKWHEAT PLANTS, 439

PREFACE TO SECOND EDITION (NEW SERIES).

It being necessary to publish a new edition of the Reports of the Geological Survey, it is thought proper to change the arrangement of the reports in the several volumes. This is advisable in order to bring together in one volume the several reports relating to a given subject or locality. In the first edition (second series) the volumes were made up of reports, regardless of subjects treated, and in order to learn all that may be published of a locality, the reader must examine several volumes. For instance, the reports on the iron ores and the iron manufacture of Greenup, Carter, Boyd, and Lawrence counties is in volume 1, and the Report on the Geology of the above named counties is in volume 2. The Chemical Reports and the reports on the Timbers are scattered through four volumes. This arrangement of reports could not have been avoided in the early history of the Survey without a delay in the publication of the volumes. It is thought that the arrangement in this edition will more fully meet the wants of the public, and will render the reports more valuable.

The first volumes of this edition will comprise the following: Chemical Analyses, Reports on the Eastern Coal Field; Reports on the Western Coal Field; Reports on Timbers. Other volumes will be published from time to time, preserving the same order of grouping reports. Some of the preliminary reports contained in the first edition have been omitted, in order that there may be no duplication when the final reports are published. I am of the opinion that enough preliminary or reconnoissance work has been done by the Survey, and the work will be directed with a view of securing (so far as the means will permit) complete reports on the geology, soils, timbers, etc., of the various regions

studied. As the stereotyped plates of the omitted preliminary reports are preserved, new editions may be ordered should there be a demand for them. A change has also been made in the size of the volume by decreasing the size of the margin, which, it is thought, will make the volume a more convenient size, both for library use and for sending through the mails.

JOHN R. PROCTER,
State Geologist.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

CHEMICAL REPORT

OF THE

SOILS, MARLS, CLAYS, ORES, COALS, IRON FURNACE PRODUCTS, MINERAL WATERS, &C., &C., OF KENTUCKY,

BY ROBERT PETER, M. D., &C., &C.,

CHEMIST TO THE KENTUCKY GEOLOGICAL SURVEY.

ASSISTED BY

JOHN H. TALBUTT, S. B., CHEMICAL ASSISTANT.

THE FIRST CHEMICAL REPORT IN THE NEW SERIES AND THE FIFTH SINCE THE BEGINNING OF THE SURVEY.

INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE
KENTUCKY STATE GEOLOGICAL SURVEY,
LEXINGTON, KY., April 19th, 1875.

Professor N. S. SHALER, *Chief Geologist, &c.:*

DEAR SIR: I have the pleasure herewith to report the results of the chemical work performed in this laboratory, for the State Geological Survey, since September, 1873, to nearly the present date. So much could not have been effected but for the able and efficient assistance of Mr. John H. Talbutt, who has given his constant attention to this labor.

Very respectfully,

ROBERT PETER.

CHEMICAL REPORT

OF THE

SOILS, MARLS, CLAYS, ORES, COALS, IRON FURNACE PRODUCTS, MINERAL WATERS, &c., &c., OF KENTUCKY.

By ROBERT PETER, M. D., &c., &c.

In the eighty-six *soil* analyses, which are appended, only a portion of ten counties of the State is represented, and the greater number of these soils are not to be classed amongst our most fertile. The limits of the range of variation of their several constituents is shown in the following table, viz:

	Pr. ct.	No.	County.		Pr. ct.	No.	County.
Organic and volatile matters vary from	7.985	in 1300	of Boyd	to	1.815	in 1398	of Carter.
Alumina and iron and manganese oxides vary from	15.763	in 1396	of Carter	to	2.740	in 1571	of Hardin.
Lime carbonate varies from	3.890	in 1330	of Campbell	to	.045	in 1572	of Hardin.
Magnesia varies from	.520	in 1329	of Campbell	to	.034	in 1298	of Boyd.
Phosphoric acid varies from	.555	in 1424	of Fayette	to	.045	in 1396 in 1566	of Carter. of Hardin.
Potash varies from	.662	in 1396	of Carter	to	.062	in 1325 in 1327	of Campbell. of Campbell.
Soda varies from	.286	in 1407	of Carter	to	trace.	in 1567	of Hardin.
Sand and insoluble silicates vary from	74.840	in 1396	of Carter	to	92.455	in 1634	of Ohio.
Water expelled at 380° F. varies from	2.650	in 1558	of Hardin	to	.225	in 1572	of Hardin.
Water expelled at 212° F. varies from	5.075	in 1329	of Campbell	to	.800	in 1571	of Hardin.

The extremes may represent very rich and very poor soils; but not the general character of the soils of the counties named.

The *method* of analyses of the soils does not vary much from that described in volume III of the Kentucky Geological Reports. The principal object was, as there stated, to obtain *comparative results*, which would enable the scientific agriculturist to form an opinion as to the *chemical constitution* of our soils in their relation to husbandry; without attempting to perform the almost hopeless task of giving all the minuter constituents of each, or of presenting all those *physical conditions* which exert so great an influence on their practical fertility. To this end the several soils were treated as nearly alike as possible: air-dried together, digested for an equal time at nearly the same temperature in acid of a uniform strength, &c., &c. The specific gravity of the chlorohydric acid used being about 1.10.

The process of digestion in water, containing carbonic acid, was not employed in all, because of the press of work in the laboratory, mainly. There can be no doubt, however, that, used with proper care, this process will indicate the relative proportion of soluble plant food in the soil at the time. As this may very well vary, under different physical atmospheric conditions, it was not considered of essential value in the comparative analyses.

The well-known fact that various *physical conditions* exert a powerful influence on the productiveness of soils which have a similar chemical composition, has, in recent times, singularly perverted the minds of chemists, and consequently of agriculturists, in relation to the value of soil analyses. Because the *chemical conditions* of a soil are not the *only ones* necessary to productiveness, they have, by a perverted logic, jumped to the conclusion that these conditions are of no consequence whatever.

But if these *chemical conditions* are *indispensable* to the fertility of the soil, how much injury has been done in recent years to the scientific study of the soil and of agriculture, by the great outcry which has been raised against this kind of investigation! The comparative chemical examination of the soils of a State or country can only be made under the patron-

age of the government. Individual efforts are inadequate to effect it; nor could they, if adequate, so economically conduct it. The writer believes that the geological survey of any region should always include this study of the soils; yet very little has been done in this direction in all the recent State surveys, and a valuable opportunity has been lost, which in many instances cannot recur, of studying the chemical conditions of the virgin soil of various parts of our country.

Chemists are naturally somewhat averse to soil analysis; it requires so much time and labor, so much care must be taken to secure accuracy, and there is so little variety in the work, and so small an appreciation of its value and significance amongst the people when done, that they gladly avoid it. But, in the course of time, most of them who are not too much prejudiced against the teachings of experience, arrive at the same conclusion with Prof. Aug. Voelcker, of the English Royal Agricultural College: "There was a time when I thought with many other young chemists, that soil analyses would do every thing for the farmer; three or four years of further experience and hard study rather inclined me to side with those men who consider that they are of no practical utility whatever; and now, after eighteen years of continued occupation with chemico-agricultural pursuits, and, I trust, with more matured judgment, I have come to the conclusion that there is hardly any subject so full of practical interest to the farmer as that of the chemistry of soils. The longer and more minutely soil investigations are carried on by competent men, the greater, I am convinced, will be their practical utility."—*Jour. of Roy. Agr. Soc. of Eng.*, 1865.

Even Prof. S. W. Johnson, whose somewhat harsh criticism, in 1861, of some of the former labors in this field of the writer, seemed to sound the key-note of the clamor against this kind of study in this country, has so far yielded his opposition as to give us in his valuable work, "*How Crops Feed*," 1870, the comparative analyses of several soils, and to point out the significance of their chemical composition. But he is careful to caution the reader, page 368, that although the analysis may

show the amount of the mineral fertilizers in a soil, it cannot tell how much of them "is at the disposal of the present crop;" and on page 271: "These facts show how very far chemical analysis, in its present state, is from being able to say definitely what any given soil can supply to crops, *although we owe nearly all our precise knowledge of vegetable nutrition directly or indirectly to this art.*"

He might very truly have added, that we should not be able to say that a suitable *chemical* composition of a soil was not the only condition necessary to its fertility, unless we had thoroughly studied that condition. It is only by means of chemical analyses that we find out the equally indispensable nature of the physical conditions. He cannot fail to admit that it is impossible to make progress in our knowledge of the soil and its actions and conditions without a thorough study of its chemical characters.

In accordance with this outcry against this sort of investigation the difficulties of obtaining good samples for analyses has been exaggerated. In a country like that of most of this State, where there is comparatively but little quarternary or transported material constituting the soil, and especially before its character has been much altered by a dense population, there is little difficulty, with the use of necessary precautions, in obtaining representative samples of large areas similar in character and position. In many large districts in our State the soil has been formed in place by the disintegration of the rocks. In other parts, where surface action has been greater, more judgment and care must be exerted in the collection of the soils; but in no part of the State, probably, is so great local variety to be seen in the soils as frequently may be observed in the northeastern States, where the transporting action of water and of ice, in former epochs, has produced a high degree of local irregularity in the nature of the surface deposits.

In the collection of the samples of our Kentucky soils the causes of local and accidental differences of composition were, as much as possible, avoided.

Because of the very small proportion of the essential ingredients of the soil, which are carried off in crops, as compared with the whole amount of the earth, taken to the depth through which the roots of plants absorb nourishment, it has been denied that it is possible by chemical analysis to show their diminution in the old field soil, as compared with the virgin soil. Indeed it has been *logically* demonstrated to be impossible. But, it should be recollected that when, by the acid digestion, we separate these essential soluble ingredients from the greater mass of the soil, left as *sand and insoluble silicates*, which amount to from about seventy-five to ninety-two per cent. of the whole, the probabilities of error in the determination of these minuter ingredients must not be calculated into the whole weight of the soil, but into that smaller part which we have thus extracted from it.

Logic apart, the *fact* still remains, that in one hundred and forty-nine duplicate analyses, made by the writer for the Kentucky, Arkansas, and Indiana Surveys, in which the chemical composition of the virgin soil was compared, under similar conditions of treatment, with soil of a neighboring old field in the same locality, one hundred and twenty-two out of the one hundred and forty-nine showed a marked diminution of most of the essential ingredients of the soil in that of the old field as compared with the virgin soil. This certainly is not an accidental result.

In the soil analyses at present reported the results are not so striking in this relation. Partly because the samples had not, in several cases, been collected with special reference to this investigation, and partly because of greater local variations of the soil in the regions in which they were obtained.

In calculating the probable amount of exhaustion of the essential soil ingredients, it should be recollected that as much, and sometimes more, may be alienated from the soil by the solvent action of the atmospheric agents, while the surface is much exposed in the cultivation of hoed crops, than is absorbed and removed by the products. Hence the exhaustion of the soil is much more rapid under these cir-

cumstances than is generally allowed. In other words, the exhaustion of the soil when under cultivation in hoed or plowed crops, during which time a large portion of its surface is kept bare of vegetation and subjected to the leaching action of rains, is much greater than can be accounted for by the amount of the essential ingredients which are taken from it in its products.

In several instances, in the analyses of the soils described above, the "sand and insoluble silicates," left after digestion, for ten days in the acid, were analyzed by the admirable process of Professor J. Lawrence Smith, for the determination of the amount of fixed alkalies held in the form of insoluble silicates. As will be seen, in the detailed report and in the tables, the quantity of potash and soda thus held in the soil in the samples in question are, in most cases, considerable, ranging from 0.485 to 2.731 per cent. of potash to the whole soil, and 0.165 to 1.306 per cent. of soda.

It is evident that, although at *present insoluble*, and hence unavailable for plant nourishment, these alkalies are doubtless gradually released and brought into a soluble form by weathering and under the influence of the products of vegetable decay, so that they tend to prolong the fertility of the soil.

The seventeen *limestone* and *lime* analyses, of specimens from nine counties only, represent but a small part of our various lime rocks. But even these exhibit their great industrial value, including, as they do, limestones useful for the fluxing of our iron ores, as well as for purposes of construction in the form of building stone or cement, while some of them would be valuable as fertilizers on the land. The so-called lithographic stone of Barren county and of other corresponding localities may, for some purposes, with well-selected samples, replace the more costly foreign stone.*

The eighty-two *iron ores* which have been analyzed are from eleven counties, principally of the northeastern portion of the

*NOTE.—I have found it impossible to use this stone for crayon or transfer work.
N. S. SHALER.

State. Sixty-four of these are limonite ores; twenty-seven are clay ironstones or carbonate ores; and only one, to be found probably only in limited quantity in Lawrence county (see No. 1594), is of the red hematite variety.

The proportion of metallic iron, in the limonite ores examined, varies from 19.344 per cent. to 57.148 per cent. In the carbonate ores analysed the per centage of metallic iron ranges from 10.960 per cent. in what may be termed only a ferruginous limestone, up to 40.465 per cent.

Of the one hundred and ten specimens of *coal*, &c., which were examined by proximate analysis, eighty-nine were from eleven counties in Kentucky; of which five counties, viz: Boyd, Carter, Greenup, Lawrence, and Menifee, are in our northeastern coal field; and six, viz: Butler, Edmonson, Grayson, Hopkins, Muhlenburg, and Ohio counties, are in the southwestern coal field. All these coals are of the splint, dry coal, or semi-cannel coal variety; cleaving generally into thin layers, which have more or less fibrous coal between them. Although some of them make a good coke, they do not generally soften or swell much when heated or burnt, and hence, when they do not contain an unusual quantity of sulphur, they can be used, without preliminary coking, for the smelting of iron. Some of these coals, however, are quite sulphurous, and some contain a large proportion of ash,† but the better samples compare favorably with the best coals of the neighboring States.

For the purpose of this comparison seven of the best coals of the State of Ohio, two of the best of those of Illinois, and four of the celebrated "block coals" of Indiana, used there for iron smelting, &c., were submitted to similar processes of analysis with our Kentucky coals. We give the general comparative results in the following tables:

† In some cases, as the samples for analysis were taken from new and imperfect openings, it is more than probable the coals will be found to be better than is represented in the analyses given.

AVERAGE COMPOSITION OF THE COALS FROM THE NORTHEASTERN KENTUCKY COAL FIELD.

COUNTIES.	Number of samples analyzed.	Specific gravity.	Volatile combustible matters.	Fixed carbon in the coke.	Per cent. of ash.	Per cent. of sulphur.
Boyd	13	1.337	33.43	54.35	*8.46	†2.292
Carter	16	1.331	33.39	53.45	8.17	‡1.886
Greenup	14	1.375	34.50	52.20	9.37	3.165
Lawrence	6	1.326	36.27	53.85	6.86	1.285
Menifee	2	1.319	33.55	53.42	10.36	2.544
General average	51	1.3376	34.23	53.45	8.62	2.234

AVERAGE COMPOSITION IN THE SOUTHWESTERN COAL FIELD.

COUNTIES.	Number analyzed.	Specific gravity.	Volatile combustible matters.	Fixed carbon.	Per cent. of ash.	Per cent. of sulphur.
Butler	1	1.378	30.66	54.94	11.00	2.544
Edmonson	8	1.360	34.01	52.34	10.56	3.312
Grayson	8	1.385	31.17	49.78	§14.38	2.083
Hopkins	2	1.385	32.95	52.55	11.20	5.019
Muhlenburg	11	1.312	36.42	53.26	6.74	2.949
Ohio	3	1.362	34.90	53.77	8.16	3.103
General average	33	1.3636	33.70	52.77	10.34	3.166

* By leaving out the exceptional ash of No. 1291, the average is = 7.94.
† Without No. 1291 this average would be = 2.036.
‡ This is the average of fifteen of the coals only.
§ By leaving out the exceptional ash of No. 1454, the average would be = 12.21.

AVERAGE COMPOSITION OF THE SELECTED COALS FROM NEIGHBORING STATES.

STATES.	Number analyzed.	Specific gravity.	Volatile combustible matters.	Fixed carbon in the coke.	Per cent. of ash.	Per cent. of sulphur.
Ohio	7	1.327	34.51	55.17	6.43	1.494
Illinois	2	1.310	31.95	59.06	5.96	1.924
Indiana	3	1.313	35.93	54.24	7.23	1.946
General average	12	1.317	34.13	56.12	6.54	1.768

This comparison is more or less imperfect, because the samples, which were too few in number to make it complete, were not averaged with special reference to it. Yet it measurably corroborates opinions held by geologists and others in regard

to our two coal fields. For instance, it will be seen in the general averages that the coals of the southwestern field have more ash and sulphur, and a higher specific gravity, than those of the northeastern, and that the relative proportions of the combustible matters, volatile or fixed, are less in the former The differences, however, are not very remarkable.

In each of these particulars the coals from our neighboring States of Ohio, Illinois, and Indiana, show less difference than might have been expected, in view of the fact that they had been collected from some of the most celebrated coal mines, as representing the *best coals* of those States. The following tables illustrate this:

TABLE OF THE EXTREMES OF COMPOSITION OF THE COALS.

COUNTIES.	Volatile combustible matters. From	Fixed carbon. From	Ashes. From	Sulphur. From
Boyd	29.70 to 36.70	46.86 to 57.90	5.10 to 14.74	1.285 to 5.361
Carter	27.22 to 36.26	44.64 to 58.88	3.20 to 12.10	.724 to 3.483
Greenup	31.66 to 37.70	47.00 to 56.70	5.40 to 13.00	.746 to 5.934
Lawrence	33.90 to 39.00	47.84 to 57.80	1.80 to 13.70	.736 to 3.785
Menifee	33.06 to 34.04	50.24 to 56.60	7.40 to 13.06	.997 to 4.092
Greatest extremes	27.22 to 39.00	44.64 to 58.88	1.80 to 14.74	.724 to 5.361
Butler	30.66	. . . . .	11.00	2.544
Edmonson	32.00 to 39.00	45.46 to 54.26	6.94 to 14.34	1.059 to 8.685
Grayson	25.86 to 35.80	40.14 to 55.52	7.50 to 29.60	.777 to 3.565
Hopkins	30.00 to 35.90	51.10 to 54.00	6.90 to 15.50	2.759 to 7.280
Muhlenburg	30.60 to 43.08	49.80 to 58.80	3.72 to 11.80	.640 to 4.032
Ohio	33.50 to 36.20	52.20 to 55.10	7.10 to 9.00	2.837 to 3.332
Greatest extremes	25.86 to 43.08	40.14 to 58.80	3.72 to 29.60	.640 to 8.685
State of Ohio	29.68 to 36.68	54.16 to 57.06	4.20 to 8.72	.756 to 2.247
State of Illinois	31.86 to 32.04	55.64 to 59.54	5.16 to 6.76	1.376 to 2.472
State of Indiana	35.10 to 36.38	53.50 to 53.58	5.28 to 9.00	1.664 to 2.373
Greatest extremes	29.68 to 36.38	53.50 to 59.54	4.20 to 9.000	.756 to 2.472

TABLE OF THE COMPOSITION OF ELEVEN SELECTED KENTUCKY COALS FROM SEVERAL COUNTIES.

COUNTIES.	Number.	Specific gravity.	Volatile combustible matters.	Fixed carbon in coke.	Per cent. of ash.	Per cent. of sulphur.
Boyd	1286	1.308	33.30	57.60	5.80	2.480
Boyd	1289	1.320	34.50	55.40	5.10	1.285
Carter	1346	1.288	34.36	54.60	4.40	.724
Carter	1347	1.290	27.22	55.88	7.50	.973
Carter	1353	1.274	34.50	58.50	3.20	2.164
Edmonson	1418	1.336	35.14	54.26	6.94	2.706
Greenup	1492	1.292	33.90	56.70	6.20	.746
Greenup	1493	1.289	34.96	55.54	5.40	1.590
Hopkins	1579	1.322	35.90	54.00	6.90	2.759
Lawrence	1589	1.281	35.30	57.80	1.80	.736
Lawrence	1593	1.284	39.00	54.76	3.74	1.066
General average		1.298	34.36	56.18	5.18	1.566

To show the great importance of collecting true and faithful *average samples* of the coal beds, for the purpose of analysis, *two picked cabinet specimens* were taken and analyzed, to-wit:

No. 1280 (*b*). *Coal No. 7, from Turkey-pen Hollow, Boyd county.*

No. 1348 (*b*). *Coal No. 7, Pritchard's coal, Mt. Savage Furnace, Carter county.*

The comparative results of the analyses are as follows—thoroughly air-dried:

	Picked sample. No. 1280 (*b*).	Ave'ge sample. No. 1280 (*a*).	Picked sample. No. 1348 (*b*).	Ave'ge sample. No. 1348 (*a*).
Specific gravity	Not determ'd.	1.358	Not determ'd.	1.435
Hygroscopic moisture	4.70	3.40	4.50	5.40
Volatile combustible matters	34.30	32.30	37.10	32.70
Coke	61.00	64.30	58.40	61.90
Total	100.00	100.00	100.00	100.00
Total volatile matters	39.00	35.70	41.60	38.10
Carbon in the coke	59.04	55.40	56.40	52.52
Ash	1.96	8.90	2.00	9.38
Total	100.00	100.00	100.00	100.00
Per centage of sulphur	0.983	1.230	0.571	2.356

As the value of a coal bed bears a very near relation to that of its average product, it is easily to be understood that the analysis of a *selected* sample may be of very little utility. On the other hand, the selection of a true average sample of the bed may often be a task of considerable difficulty.

The determination of the proportion of *sulphur* in coals has been much neglected in this country; and where it has been done the method generally used has been to oxidate the powdered coal in strong nitric or nitro-hydrochloric acid. This mode of analysis is not so perfect as fusion with a mixture of nitre, carbonate of soda, and salt, &c., which always, when properly managed, brings all the sulphur into the form of soluble sulphate, in whatever state it may have existed in the coal. This exhaustive mode was employed in all our estimations of this substance, and hence the quantities obtained may seem greater than are shown to exist in similar coals which have been treated with the acids.

As has now been extensively demonstrated, the sulphur in coals is rarely all combined with iron as sulphide or bi-sulphide. Some frequently exists in a free or uncombined condition, as is shown in an analysis described in the following pages. Some of it is frequently in the form of lime sulphate.

When it is recollected that vegetable matters, decomposing in a solution of sulphates of lime, magnesia, iron, &c., reduce these salts to sulphides, with the production of hydrogen sulphide in the case of the earthy salts, and when we reflect that this gaseous compound, HS, is decomposed, with the deposition of free sulphur, on contact with the air, we can easily understand how most of our coals must contain not only pyrites but free sulphur.

In the thirty-four *marls*, *marly shales*, *sands*, and *silicious concretions*, which have been analyzed, we find a general prevalence of lime, fixed alkalies, phosphoric acid, sulphuric acid, &c. Some of the marls and shales contain these in such considerable proportions as to make them locally useful for the amelioration of poor sandy land. Some of these find an application as mineral paint, for which they are adapted by their

agreeable tint and other properties. Some of the more silicious could be used in the manufacture of glass, as well as for other purposes; some of post-tertiary silicious clays, or soft sandstones, might be made into bricks for scouring purposes, &c., while others, which contain but little lime, magnesia, oxide of iron or alkalies, would prove quite refractory in the fire.

But the *fire-clays* and *plastic clays* of the coal fields, of which the analyses of sixteen are appended, are especially deserving attention; and from their abundance, superior quality, and vicinity to fuel, should form the basis of extensive industries. Amongst them may be found some of the best of fire-clays, as well as some well-fitted to the manufacture of pottery ware of various kinds, including the better sorts of delf, stone china, or queensware. Skill, capital, and enterprise are all that are needed, on these somewhat neglected deposits, to make them of very great value to individuals as well as to the public. Only the want of these essentials causes us to pay a heavy tax to foreign nations for our pottery ware, when the materials for the manufacture lie measurably neglected at home. It is simply the history repeated of the importation of bricks from Holland to build houses in Albany, and the packing of English bricks, on the backs of horses, over the Alleghenies, to construct the barracks at old Fort Duquesne on the Ohio.

The nineteen samples of *pig iron* which have been analyzed are mostly of the kind known as foundry iron. On reference to the general table of their composition, it will be seen that they present considerable variety in this respect; as for example:

The per centage of	iron	ranges between	85.455 to 95.840
"	carbon	"	2.040 to 4.400
"	phosphorus	"	0.123 to 1.029
"	sulphur	"	a trace to 0.150
The specific gravity		"	6.406 to 7.782

Of the numerous *mineral waters* of our State the analyses of twenty-one are given in the present report, mostly from one locality.

BATH COUNTY.

No. 1269—Limonite Iron Ore. "*From Block-house ore bank, one and a half miles from the Old Slate Furnace, Bath county. Bed ten to twelve feet thick; on the Clinton Group. Collected by Philip N. Moore.*"

Ore generally dense and dark-colored, with some dark ochreous ore. Structure cellular and oölitic.

COMPOSITION, DRIED AT 212° F.

Iron, peroxide	76.077	= 53.254 per cent. of iron.
Alumina	2.592	
Manganese, brown oxide	.430	
Lime, carbonate	.130	
Magnesia	.281	
Sulphuric acid	.030	= 0.011 per cent. of sulphur.
Phosphoric acid	.731	= .319 per cent. of phosphorus.
Water, expelled at red heat	12.300	
Silica and insoluble silicates	8.180	= 6.160 per cent. of silica.
	100.751	

The phosphoric acid determination was made by Chancel's process, viz: by means of acid nitrate of bismuth solution, after the separation of the iron oxide, and is believed to be nearly correct. The iron ore in the Clinton Group, especially the "dye-stone ore," is usually quite phosphatic. This does not prevent it from being quite valuable for the production of iron for many purposes, although it may not be made to yield the higher grades of bar iron or steel.

BARREN COUNTY.

No. 1421—Limestone. "*Oölitic Limestone. Upper layers of upper sub-carboniferous limestone. Glasgow Junction, Barren county. Collected by Prof. N. S. Shaler.*"

A compact, nearly white, fine oölitic limestone, with a ferruginous stain on the exposed surfaces probably derived from the superincumbent soil.

No. 1422—Limestone (*compact*). "*Upper Sub-carboniferous Limestone. Glasgow Junction. Collected by N. S. Shaler.*"

A light-grey, fine granular, or compact limestone, which might be a good lithographic stone but for the presence of some imbedded fossils and minute specks of iron peroxide.

No. 1423—LIMESTONE. *Labeled "Lithographic Stone; below the building stone. Upper sub-carboniferous limestone. Glasgow Junction. Collected by Prof. N. S. Shaler."*

A light-grey, compact, or very fine granular rock, which might be a perfect lithographic stone but for the minute imbedded fossils and the small occasional specks of iron peroxide, &c., which it contains. Some layers, however, are reported measurably free from these imperfections, and found to be good enough, on actual trial, for some ordinary lithographic purposes.

COMPOSITION OF THESE BARREN COUNTY LIMESTONES, DRIED AT 212° F.

	No. 1421.	No. 1422.	No. 1423.
Specific gravity	2.678	2.721	2.689
Lime, carbonate	98.050	77.550	82.960
Magnesia, carbonate	.363	13.214	7.655
Alumina, and iron and manganese oxides	.511	2.680	2.680
Phosphoric acid	.051	.051	.115
Sulphuric acid	.260	.192	.260
Potash	.115	.154	.135
Soda	.327	.188	.156
Silica and insoluble silicates	1.060	6.060	6.160
Total	100.737	100.189	100.121
Per centage of lime	50.428	43.428	46.457
Per centage of phosphorus	.022	.022	.050
Per centage of sulphur	.104	.077	.104

No. 1421 would yield a very pure white lime.

BOYD COUNTY.

No. 1270—CLAY IRON-STONE, &c. *Labeled "Grey Limestone Ore. J. P. Jones' drift, near Ashland. Averagc sample selected by P. N. Moore."*

A mixed sample, with oölitic carbonate of iron, dark grains united with a whitish cement, portions of compact carbonate, and of *limonite* ore.

No. 1271—CLAY IRON-STONE. *Labeled "Wilson Creek Blue Block Ore. Average sample, taken from Star Furnace stock pile, by P. N. Moore."*

A fine-granular ore of various shades of dark-grey, with some slight incrustations of limonite. Not adhering to the tongue.

No. 1272—CLAY IRON-STONE. *Labeled "So-called Limestone Ore, from Williams' Creek. Star Furnace stock pile. Averaged by P. N. Moore."*

A granular and oölitic proto-carbonate of iron (containing much carbonate of lime). Oölitic grains nearly black, in a whitish cement.

SUMMARY OF THE COMPOSITION OF THESE BOYD COUNTY CLAY IRON-STONES, DRIED AT 212° F.

	No. 1270.	No. 1271.	No. 1272.
Iron, carbonate	32.285	66.854	19.802
Iron, peroxide	12.784	.276	21.433
Alumina (by difference)	11.968	4.260	1.193
Lime, carbonate	21.125	2.460	30.205
Magnesia, carbonate	.691	4.086	a trace.
Manganese, carbonate	.465	.572	.240
Phosphoric acid (anhydr.)	.377	.709	.257
Sulphuric acid (anhydr.)	.267	.885	.157
Silica and insoluble silicates	19.730	18.360	23.080
Water and loss	.308	1.538	3.633
Total	100.000	100.000	100.000
Per centage of iron	24.591	32.466	23.109
Per centage of phosphorus	.164	.308	.112
Per centage of sulphur	.107	.354	.063
Per centage of silica	.....	15.500	18.960

Of these ores, No. 1271 would be the best, as it is the richest; but its considerable proportions of phosphorus and sulphur will somewhat injure the toughness of the iron it

yields. No. 1272 is not so objectionable in this respect. This ore as well as No. 1270, containing a large proportion of lime, although comparatively poor in iron, may yet be profitably smelted, especially in mixture with richer ores. They will obviously require less fluxing material than the other ores.

No. 1273—LIMONITE. *Labeled "Slate Ore. Head of Cane Creek, on the road to Star Furnace, Boyd county. Average sample selected by P. N. Moore."*

In irregular curved layers, varying in hardness and color from yellowish-brown to blackish-brown; frequently inclosing soft ochreous nodules.

No. 1274—LIMONITE. *Labeled "Yellow Kidney Ore, sampled from a number of places by P. N. Moore. Star Furnace property."*

Irregular curved layers of dark-colored limonite (brown hæmatite), incrusted by and inclosing soft ochreous ore.

No. 1275—LIMONITE. *Labeled "Limestone Ore;" average sample selected by P. N. Moore. Bellefont Furnace.*

Ore varying from brownish-yellow to dark brown (mostly dark brown), with some proto-carbonate of iron, ferruginous limestone, and a little calc. spar intermixed.

No. 1276—LIMONITE. *Labeled "Yellow Kidney Ore;" average sample selected by P. N. Moore. Buena Vista Furnace.*

Irregular curved layers of limonite, varying from *soft*, brownish-yellow to *dense*, dark brown ore.

No. 1277—LIMONITE, &C. *Labeled "Yellow Kidney Ore, or Kidney Ore below the No. 7 Coal." Straight Creek, Buena Vista Furnace. Average sample collected by P. N. Moore.*

Limonite layers of various depth of color, with some fine granular carbonate of iron and thin veins of calc. spar.

No. 1278—LIMONITE. *Labeled "Black Kidney Ore." Average sample, from Stock Branch Hollow, just south of Star Furnace. Collected by P. N. Moore.*

In irregular curved layers, generally of a dark purplish-brown color, with some soft ochreous nuclei and layers.

SUMMARY OF THE COMPOSITION OF THESE BOYD COUNTY LIMONITES, DRIED AT 212° F.

	No. 1273.	No. 1274.	No. 1275.	No. 1276.	No. 1277.	No. 1278.
Iron, peroxide	53.653	58.960	51.802	61.344	56.022	54.055
Iron, carbonate	.....	.....	10.594	.....	8.821	.....
Alumina (by difference)	4.324	7.284	4.523	4.236	7.194	4.919
Manganese, brown oxide	.368	.380	a trace.	a trace.	a trace.	.420
Lime, carbonate	a trace.	.430	7.480	.750	2.520	.080
Magnesia	.101	.227	.440	.208	1.271	a trace.
Phosphoric acid (anhydr.)	.313	.376	.570	.795	.526	.076
Sulphuric acid (anhydr.)	.220	.206	.089	.041	.090	.096
Combined water	10.150	10.800	8.772	11.200	10.126	10.450
Silex and insoluble silicates	30.940	21.210	15.730	21.480	13.430	30.080
Moisture and loss	.....	.127	....	.....	.....	.....
Total	100.069	100.000	100.000	100.054	100.000	100.176
Per centage of iron	37.551	41.272	41.357	42.941	43.473	37.838
Per centage of phosphorus	.137	.164	.231	.347	.229	.033
Per centage of sulphur	.086	.082	.035	.016	.036	.038
Per centage of silica	29.560	19.980	13.160	18.560	11.660	24.260

These are all good ores; Nos. 1273 and 1278 being the poorest in iron and the most silicious. The proportion of *sulphur* is small in all of them, and of phosphorus is probably not enough to injure the iron for ordinary uses. Nos. 1275 and 1277 would probably be improved for smelting by a previous roasting.

No. 1279—COAL. *Labeled "Coal No. 7, from drift one quarter mile above the store, on Furnace Branch of Straight Creek, Buena Vista Furnace. Average sample of both parts of the bed, by P. N. Moore."*

No. 1280—COAL. *Labeled "Coal No. 6, from Turkey-pen Hollow; Old Clinton Tract; Bellefont Furnace. Averaged by P. N. Moore."*

No. 1281—COAL. *Labeled "Coal No. 7, three feet thick, no parting; Chadwick Creek. Average sample, selected by A. R. Crandall."*

No. 1282—COAL. *Labeled "Coal No. 5, eighty-five feet below the yellow kidney ore, drift south side of Straight Creek, one third of a mile from Buena Vista Furnace. Averaged by P. N. Moore."*

No. 1283—COAL. *Labeled "Keys Creek Coal, No. 6. Average sample collected by A. R. Crandall."*

No. 1284—COAL. *Labeled "Coal No. 3, from drift on Hood's Creek, one third of a mile southeast of Bellefont Furnace. Average sample collected by A. R. Crandall."*

A splint coal, exhibiting some fibrous coal and fine particles of pyrites between the layers.

No. 1285—COAL. *Labeled "Coal No. 6, from Horse Branch (or Run), near Catlettsburg, Boyd county. Average sample, collected by A. R. Crandall."*

A splint coal. Some fibrous coal between the layers, with a little ferruginous incrustation.

No. 1286—COAL. *Labeled "Coal No. 7, from the Ashland Company's mine No. 4, Coalton, Boyd county. Average sample, by P. N. Moore."*

A dark, glossy, splint coal, with some fibrous coal between the layers.

No. 1287—COAL. *Labeled "Coal No. 7, from entry No. 4; cross-entry; slate roof; Dry Branch. Average sample, by P. N. Moore."*

A jet-black pure-looking coal.

No. 1288—COAL. *Labeled "Coal No. 7, three hundred yards from the end of No. 4 entry. Trace Creek, Boyd county. Averaged by P. N. Moore."*

A pure jet-black coal. Very little fibrous coal or pyrites apparent.

No. 1289—COAL. *Labeled "Coalton Coal, No. 7. Two hundred and fifty yards from west end of No. 4 entry, &c. Averaged by P. N. Moore."*

Contains more fibrous coal and pyrites than the two preceding.

No. 1290—COAL. *Labeled "Coalton Coal, No. 7, from Mr. Bryan's Bank, Four Mile Creek, Boyd county. Collected by A. R. Crandall. Average sample."*

Jet black. Contains very little pyrites or fibrous coal.

No. 1291—COAL. *Labeled "Coal No. 11. Wm. A. Bolt's coal. East Fork of Little Sandy river, above Bolt's Fork, Boyd county. Average sample, collected by A. R. Crandall."*

A jet-black coal. But little fibrous coal or pyrites apparent.

[See Appendix, No. 1645, for analysis of another Boyd county coal.]

COMPOSITION OF THESE BOYD COUNTY COALS, DRIED AT 212° F.

	No. 1279.	No. 1280.	No. 1281.	No. 1882.	No. 1283.	No. 1284.	No. 1285.	No. 1286.	No. 1287.	No. 1288.	No. 1289.	No. 1290.	No. 1291.
Specific gravity	1.328	1.358	1.304	1.360	1.279	1.366	1.315	1.308	1.340	1.336	1.320	1.365	1.404
Hygroscopic moisture.	6.50	3.40	3.50	3.20	2.94	3.20	2.70	3.30	4.40	4.06	5.00	4.00	2.60
Volatile combus. mat'rs.	33.90	32.30	34.10	32.30	32.56	29.70	36.70	33.30	31.10	34.24	34.50	34.06	35.80
Coke	59.60	64.30	62.31	64.50	64.50	67.10	60.60	63.40	64.50	61.70	60.50	61.94	61.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters .	40.40	35.70	37.60	35.50	35.50	32.90	39.40	36.60	35.50	38.30	39.50	38.06	38.40
Fixed carbon in coke .	52 78	55.40	55.30	53.00	56.70	55.10	52.60	57.60	57.90	54.70	55.40	53.20	46.86
Ashes	6.82	8.90	7.10	11.50	7.74	12.00	8.00	5.80	6.60	7.00	5.10	8.74	14.74
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke .	Dense.	Dense.	Dense.	Dense.	Spongy.	Friable.	Spongy.	Mod. dense.	Spongy.	Spongy.	Spongy.	Spongy.	Spongy.
Color of the ash . . .	Light lilac-grey.	Light purple-grey	Purple-grey.	Lilac-grey	Lilac-grey.	Drab-grey.	Dark lilac-grey.	Light lilac-grey.	Lilac-grey.	Lilac-grey.	Light br'wn-grey.	Dove colored.	Brownish grey.
Per centage of sulphur.	3.765	1.230	2.370	1.999	1.972	1.793	1.711	2.480	2.095	1.854	1.285	1.890	5.361

23

With a few exceptions these may all be considered very good coals. These few contain rather too large a proportion of ash. This will not prevent them from being very good fuel for ordinary purposes. Some of them have a notable proportion of sulphur, which may render them measurably unsuitable for the working of iron, but which will not be otherwise injurious. It may be remarked, however, that the estimation given above is of the *total amount* of sulphur in the coal, in whatever form of combination it may exist. The analyses for the determination of the sulphur having been made by deflagrating the powdered coal with a mixture of nitre, carbonate of soda, and common salt (each chemically pure, of course), and not by the usual process of oxidation with nitric acid, &c., the extraction of the sulphur is therefore more complete than usual. These are all splint coals.

The relation between the specific gravity and the proportion of ash does not seem to be a constant one, as may be seen in the following statement:

Specific gravity	1.279	Per centage of ash	7.74
"	1.304	"	7.10
"	1.308	"	5.80
"	1.315	"	8.00
"	1.320	"	5.10
"	1.328	"	6.82
"	1.336	"	7.00
"	1.340	"	6.60
"	1.358	"	8.90
"	1.364	"	11.50
"	1.365	"	8,74
"	1.366	"	12.00
"	1.404	"	14.74

In the appendix are given, for comparison, the analyses of some of the most celebrated Indiana, Ohio, and Illinois coal, which are used in the smelting of iron, &c.

No. 1292—MARLY SHALE. *From near the top of the ridge between Clinton Furnace and Cannonsburg, Boyd county.*

A friable indurated marly clay, of dirty-greenish and brownish colors.

COMPOSITION DRIED AT 212° F.; AS DETERMINED BY DIGESTION IN CHLOROHYDRIC ACID, &c.

Alumina, and iron and manganese oxides	12.643
Lime, carbonate	.480
Magnesia	.929
Phosphoric acid	.217
Sulphuric acid	.079
Potash	1.387
Soda	.080
Water expelled at red heat	5.830
Silica and insoluble silicates	77.560
Loss	.795
	100.000

On treating this marl, by ignition with carbonate of lime and chloride of ammonium, for the complete separation of its alkalies, according to the method proposed by Prof. J. Lawrence Smith, we obtained a total of 3.989 per cent. of *potash* and 0.639 per cent. of *soda*. So that about two thirds of the potash is in such a state of combination, in the silicates of this marly clay, as to resist the solvent action of chlorohydric acid, of specific gravity 1.1, although digested for eight or ten days in the sand-bath heat. Possibly admixture with slacked quicklime might help to set free this considerable proportion of alkali, and make it an available mineral fertilizer for exhausted light soils.

No. 1293—PIG IRON. "*Hot Blast No. 1, Bellefont Furnace, Boyd county. Collected by P. N. Moore.*"

A moderately coarse-grained dark-grey iron. Yields to the file, and extends somewhat under the hammer.

No. 1294—PIG IRON. "*Hot Blast No. 1, Foundry, Buena Vista Furnace. Collected by P. N. Moore.*"

A coarse-grained grey iron. Yields to the file; extends a little under the hammer.

No. 1295—PIG IRON. "*Mill Iron No. 1, Ashland Furnace, Boyd county. Stone-coal Iron. Sent by Col. Douglas Putnam, jr.*"

A very fine-grained light-grey iron. Yields to the file. Brittle.

No. 1296—PIG IRON. "*Mill Iron No. 2. Stone-coal Iron. Ashland Furnace. Sent by Col. Douglas Putnam, jr.*

Not quite so fine-grained as the preceding. Light-grey. Yields to the file. Brittle.

No. 1297—PIG IRON. *Foundry Iron. Ashland Furnace, &c., &c. (as above). Coarser-grained than the preceding.*

Yields to the file. Brittle.

COMPOSITION OF THESE BOYD COUNTY PIG IRONS.

	No. 1293.	No. 1294.	No. 1295.	No. 1296.	No. 1297.
Specific gravity	7.132	7.127	6.410	6.503	6.406
Iron	93.208	93.712	91.420	90.899	89.731
Graphite	3.350	2.990	2.460	2.560	1.660
Combined carbon	.220	.210	.240	.160	.790
Manganese	.054	.056	.195	.236	.471
Silicon	2.389	1.908	3.709	5.121	6.308
Slag	1.160	.600	.540	.760	1.120
Aluminum	.193	.644	Not est.	Not est.	Not est.
Calcium	.144	.104	.176	.072	.152
Magnesium	.095	.095	.233	.106	.060
Potassium	.047	.063	Not est.	Not est.	Not est.
Sodium	.032	.010	Not est.	Not est.	Not est.
Phosphorus	.194	.380	.385	.394	.461
Sulphur	.005	.066	.082	.045	.015
			Loss .560		
Total	101.091	100.838	100.000	100.353	100.768
Total carbon	3.570	3.200	2.700	2.720	2.450

No. 1298—VIRGIN SOIL. *"From woods in the valley of East Fork of Little Sandy river, taken to six inches below the surface. Farm of Vincent Calvin, near Cannonsburg, Boyd county. Collected by J. A. Monroe."*

Soil of a dirty-buff color. All passed through the coarse sieve (289 meshes to the inch).

No. 1299—SUB-SOIL *of the preceding, &c., &c.*

Of a buff color; lighter in tint than the preceding. All passed through the coarse sieve.

No. 1300—VIRGIN SOIL. *"Southeastern slope of hill sixty feet above the bed of the creek. V. Calvin's farm, &c., &c. Sample taken six inches from the surface by J. A. Monroe."*

Of a dark dirty-drab grey color. The coarse sieve removed from it a considerable proportion of small fragments, many of which are angular, of ferruginous sandstone.

No. 1301—SUB-SOIL *of the preceding, taken two feet below the surface, &c., &c.*

Lighter colored than the preceding; dirty-drab grey. Sifted out more of ferruginous sandstone fragments than from the preceding.

No. 1302—OLD FIELD SOIL. *"Surface soil from a field forty-five years in cultivation, on East Fork of Little Sandy. Farm of V. Calvin, near Cannonsburg."*

Soil of a dirty dark-buff color. All passed through the coarse sieve.

No. 1303—"SUB-SOIL *of the next preceding, taken two and a half feet from the surface, &c."*

Of a dirty-buff color, lighter in tint than that of the surface soil. All passed through the coarse sieve.

COMPOSITION OF THESE BOYD COUNTY SOILS, DRIED AT 212° F.

	No. 1298.	No. 1299.	No. 1300.	No. 1301.	No. 1302.	No. 1303.
Organic and volatile matters.	3.140	3.085	7.985	5.190	4.915	4.905
Alumina, and iron and manganese oxides	5.091	6.642	7.425	9.984	9.019	9.675
Lime, carbonate	.214	.116	.571	.392	.259	.276
Magnesia	.034	.178	.352	.251	.333	.053
Phosphoric acid	.134	.083	.208	.191	.156	.160
Sulphuric acid	trace.	.....	.....	trace.	.038	trace.
Potash	.317	.307	.435	.205	.344	.282
Soda	.076	.099	.045	.050	.027	.176
Sand and insoluble silicates	90.490	88.420	81.410	83.230	83.765	83.385
Water expelled at 380° F.	.650	.525	.915	.500	1.235	1.315
Loss	.....	.545	.554	.007	.....	.....
Total	100.146	100.000	100.000	100.000	100.091	100.227
Hygroscopic moisture	1.375	1.735	2.225	1.700	2.335	2.840
Potash in the insol. silicates.	Not estimated.					
Soda	Not estimated.					
Character of the soil	Virgin soil. Valley.	Sub-soil.	Virgin soil. Slope of hill.	Sub-soil.	Old field.	Sub-soil.

These soils, if sufficiently drained and properly cultivated, may be made quite productive, although the silicious material is in rather large proportion in some. By comparing the composition of the virgin soil No. 1300, with that of the corresponding old field soil No. 1302, it will be seen that cropping, without the use of manures, has notably diminished the phosphoric acid, potash, and lime carbonate, while the relative proportion of the sand and silicates is increased.

[For Bourbon County Limestone, see the Appendix.]

BRACKEN COUNTY.

No. 1304—SOIL. *Labeled "Top Soil, one to eight inches from surface. Old field in grass; thin and bare in places. Sample from a fertile corner, beyond the fence where it had been out of culture for five years or more." Collected by Prof. N. S. Shaler.*

Of a dark grey-buff color. Contains no gravel or coarse sand.

No. 1305—"SUB-SOIL *of the preceding; taken fourteen to eighteen inches below the surface, just above the rock substratum. It has some faint traces of original bedding, showing that it had been formed by decomposition of rock in place. Collected by Prof. N. S. Shaler."*

Of a handsome yellowish-buff color. No gravel.

No. 1306—TOP SOIL *of the field No.* 1304; *taken in a worn place; has been longer in cultivation and is much more worn than that. Will not hold sod. Has been in cultivation over twenty years. Collected by Prof. N. S. Shaler."*

Of a yellowish-buff color, very little darker than that of the sub-soil. Contains a small quantity of small fragments of red ferruginous shale.

EXTRACTED FROM 1000 PARTS OF THESE SOILS (AIR DRIED) BY DIGESTION IN CARBONIC ACID WATER.

	No. 1304.	No. 1305.	No. 1306.
Organic and volatile matters	0.483	0.600	0.294
Alumina, and iron and manganese oxides	.013	.013	.010
Lime, carbonate	.496	.040	.080
Magnesia	.030	.023	.014
Potash	.030	.010	.020
Soda	.020	.020	.020
Soluble silica	.060	.130	.110
Phosphoric, sulphuric, and nitric acids and loss	.184	.130	.118
Total extract from 1000 parts	1.316	0.960	.666
Color of the extract	Light brown.	Light brownish grey.	Brownish grey.

COMPOSITION OF THESE BRACKEN COUNTY SOILS, DRIED AT 212° F.

	No. 1304.	No. 1305.	No. 1306.
Organic and volatile matters	4.140	4.775	3.335
Alumina	5.837	5.513	3.837
Iron, peroxide	7.150	6.025	3.965
Manganese, brown oxide	.225	.170	.070
Lime, carbonate	a trace.	a trace.	a trace.
Magnesia	.297	.269	.268
Phosphoric acid	.233	.424	.217
Sulphuric acid	a trace.	a trace.	a trace.
Potash	.110	.197	.135
Soda	a trace.	.174	.076
Sand and insoluble silicates	82.140	81.970	87.815
Water expelled at 380° F.	1.015	1.100	not est.
Total	101.147	100.617	99.718
Water expelled at 212° F.	2.200	3.200	2.300

These soils are all deficient in lime. Top-dressing with this material would doubtless greatly improve their productiveness. This should, however, be accompanied with the use of clover or other green fertilizing crops, to increase the proportion of *humus*, which is also deficient in the soils. The difference in the amount of soluble matters extracted by digestion in water charged with carbonic acid, as well as the relative proportions of the potash, &c., in that extracted matter, and the amount

of sand and silicates, correspond with the observed relative productiveness of the soils.

No. 1307—SILICIOUS MUDSTONE (of Dr. Owen). *Rock below Soil No.* 1304; *averages from twenty-eight to thirty-five inches. Uniform. Some of the layers completely decomposed; all of them softened by decay. Three miles northwest of Germantown. Collected by Prof. N. S. Shaler.*

A dirty grey-buff, friable, sandy shale. Adhering to the tongue. Many fossils in the laminæ.

COMPOSITION, DRIED AT 212° F.

Silica	76.060	
Alumina, and iron and manganese oxides	14.959	(by difference).
Lime, carbonate	.500	
Magnesia, carbonate	.345	
Phosphoric acid	.486	
Potash	2.735	
Soda	1.515	
Water expelled at red heat	3.400	
	100.000	

This analysis having been made by fusion, instead of digestion in acids, &c., &c., gives the *total* contents of alkalies and phosphoric, as well that quantity which may be immediately available for plant nourishment as that which for the present is locked up in firm combination in the silicates, which can only become available in the natural course of long weathering.

BRECKINRIDGE COUNTY.

No. 1308—"RED UNDER CLAY, *from near Brandenburg. Collected by Mr. G. E. Chick.*

A somewhat adhesive ferruginous clay, of a dark brick-red color; containing some fragments of weathered chert.

COMPOSITION, DRIED AT 212° F.

Organic and volatile matters, mostly water	9.000
Alumina, and iron and manganese oxides	20.860
Lime, carbonate	1.060
Magnesia	.684
Phosphoric acid	.230
Sulphuric acid	.061
Potash (including that in the silicates)	.982
Soda (including that in the silicates)	.501
Sand and insoluble silicates	66.680
	100.058

Although this clay contains a considerable per centage of potash, nearly one per cent., it is not probable that it could be profitably used as a fertilizer, because of the fact that a very large proportion of its alkalies is in the insoluble silicates, where they would not be immediately available for plant nourishment.

It might be employed, however, to improve the condition of light sandy soils.

BUTLER COUNTY.

No. 1309—LIMONITE. *Labeled "Ore from the farm of Jas. E. Taylor, near the mouth of Little Reedy; one mile and a half from Green river. Average sample by J. R. Proctor."*

Limonite in irregular laminæ; with much softer ochreous ore.

No. 1310 — LIMONITE. *Labeled "Ore above the upper coal. Stevens' coal mine, near the mouth of Bear Creek. Average sample by P. N. Moore."*

In dense, curved, dark-brown laminæ, incrusted by and inclosing softer ochreous ore.

COMPOSITION OF THESE LIMONITES, DRIED AT 212° F.

	No. 1309.	No. 1310.
Iron, peroxide	48.049	44.794
Alumina	.171	2.391
Manganese, brown oxide	.140	a trace.
Lime, carbonate	.540	.643
Magnesia	.195	.234
Phosphoric acid	.345	.535
Sulphuric acid	.473	.158
Water expelled at red heat	9.750	7.700
Silica and insoluble silicates	31.900	44.180
Alkalies, &c., and loss	.437	. . . . .
Total	100.000	100.815
Iron, per centage	33.634	31.482
Phosphorus, per centage	.150	.233
Sulphur, per centage	.189	.063
Silica, per centage	29.460	42.200

The somewhat large proportion of *phosphorus* in these two ores may make the iron obtained from them somewhat "cold-short," and the sulphur in No. 1310 is in rather too large quantity. In other respects these ores are good, and they might be profitably smelted for ordinary foundry iron.

No. 1311—CLAY IRON-STONE. *Labeled "Ore from Jno. Hudson's on Young's Ferry road. Average sample by P. N. Moore."*

A dark grey, fine-granular iron carbonate, partly converted into limonite.

No. 1312—CLAY IRON-STONE. *Labeled "Ore resting on the coal at Knob Lick, half a mile from Big Reedy Creek, near road to Young's Ferry. Average sample by P. N. Moore."*

Granular iron carbonate, somewhat oölitic, partly converted into limonite, and containing small fragments of fibrous coal.

COMPOSITION OF THESE CLAY IRON-STONES, DRIED AT 212° F.

	No. 1311.	No. 1312.
Iron, carbonate	29.914	22.583
Iron, peroxide	17.945	17.313
Alumina	3.583	.835
Lime, carbonate	12.036	6.714
Magnesia, carbonate	3.677	2.830
Manganese, carbonate	a trace.	a trace.
Phosphoric acid	.467	.972
Sulphuric acid	.381	.473
Silex and insoluble silicates	28.040	44.240
Water and loss	3.957	4.040
Total	100.000	100.000
Iron, per centage	27.041	22.969
Phosphorus, per centage	.204	.423
Sulphur, per centage	.152	.189
Silica, per centage	25.260	42.760
Specific gravity	not est.	not est.

No. 1313—COAL. *Labeled "Stevens' coal. Stevens' bank, Bear Creek, two miles from Green river, Butler county. Average sample by P. N. Moore."*

A deep-black coal, breaking into thin layers under the hammer. Fibrous coal and fine-grained pyrites between the laminæ. Contains a little shale.

COMPOSITION OF THE AIR-DRIED COAL.

	No. 1313.
Specific gravity	1.378
Hygroscopic moisture	3.40
Volatile combustible matters	30.66
Coke	65.94
Total	100.00
Total volatile matters	34.06
Fixed carbon in the coke	54.94
Ashes	11.00
Total	100.00
Character of the coke	Spongy.
Color of the ash	Brownish lilac-grey.
Per centage of sulphur	2.544

No. 1314—LIMESTONE, *from Barren river, near the mouth of Gasper Creek; sub-carboniferous. From the stock pile of Airdrie Furnace. Sampled by P. N. Moore."*

A light-grey, fossiliferous limestone.

COMPOSITION, DRIED AT 212° F.

Lime, carbonate	93.020	= 52.091 per cent. of lime.
Magnesia, carbonate	2.088	
Alumina, and iron and manganese oxides	.917	
Phosphoric acid	.243	= 0.106 per cent. of phosphorus.
Sulphuric acid	.604	= .242 per cent. of sulphur.
Silica and insoluble silicates	2.760	
Water and loss	.368	
	100.000	

CALDWELL COUNTY.

GALENA (lead sulphide), selected from specimens sent by S. Marble & Son, Princeton, Kentucky, from their lead mine in this county. The vein is in the sub-carboniferous limestone, described as generally five feet wide. The mine has a twenty feet drift, forty-five feet wide. The gangue of the ore is principally fluor-spar, containing more or less zinc blende.

This ore was examined principally for its proportion of silver; and by a careful analysis of the lead, obtained from it by reduction with the usual flux (of soda carbonate, potash nitrate, and sodium chloride), solution of the reduced metal in diluted nitric acid, and precipitation of the filtered solution by means of a very dilute solution of lead chloride, a very small proportion of silver was obtained, not exceeding in amount two hundred and sixty-six (266) grains to the ton (of 2,000 pounds) of the selected galena. As is well-known, pure galena contains from eighty-one to eighty-six per cent. of lead in general

This mine cannot, therefore, be profitably worked for silver; but if fluor-spar is found to be practicably valuable for the purification of iron from phosphorus, &c., this, as well as the lead, may be advantageously explored.

CAMPBELL COUNTY.

No. 1315—MARLY SHALE. *Labeled "Clay Marl, from Cincinnati Group; quarter of a mile from Newport, on the Alexandria Turnpike; upper blue clay. Collected by Prof. N. S. Shaler."* Lower Silurian.

A dark-grey, soft shale. Adhering to the tongue.

No. 1316—MARL. *Labeled "Marl, from the silicious mud-stone of Dr. Owen, ten feet from the surface. Not distinctly stratified. Gallows Gap. Collected by Prof. N. S. Shaler."*

Buff-colored; friable; fine-grained.

No. 1317—CLAY SHALE. *Labeled "Newport Reservoir; three hundred and forty feet above the Ohio river. A mixture of the clays in a set of beds, containing a few limestone layers, six feet from the surface to twelve feet." Collected by Prof. N. S. Shaler.*

A yellowish, soft shale, with some softer ferruginous clay mixed. Adhering to the tongue.

No. 1318—CLAY SHALE. *Labeled "Newport Reservoir, upper blue clay, three hundred and twenty feet above high water in the Ohio river." Collected by Prof. N. S. Shaler.*

A dark, bluish-grey soft shale. Adhering to the tongue.

No. 1319—CLAY. *Labeled "Brick Clay, about three feet above high water in the Ohio river; Newport, Kentucky." Collected by Prof. N. S. Shaler.*

A light, ferruginous, yellow silicious clay.

No. 1320—SANDY FERRUGINOUS CLAY. *Labeled "Sandy Clay, three feet from surface; Mt. Vernon road, half a mile from Alexandria Turnpike." Collected by Prof. N. S. Shaler.*

Of a light reddish-brown color.

No. 1321—FERRUGINOUS CLAY, &C. *Labeled "Ferruginous Conglomerate; side of road, one mile north of Grant's Creek. North head waters of Phillips' Creek." Collected by Prof. N. S. Shaler.*

Ferruginous clay, with nodules of impure hydrated peroxide of iron included.

No. 1322—SAND. *"Labeled "Moulding Sand, Columbia Trace, half a mile northeast of Newport Water-Works Reservoir." Collected by Prof. N. S. Shaler.*

A fine sand of a dirty-salmon color, composed mainly of minute rounded quartz grains.

No. 1323—SAND. *Labeled "Sand beneath the Brick Clay. Section on Columba corner of Harris street; Newport, Kentucky." Collected by Prof N. S. Shaler.*

A moderately fine sand, of a dirty-buff color. Examined with the glass it showed mostly rounded grains of hyaline, yellow and milky quartz, with dark grains of some ferruginous mineral.

COMPOSITION OF THESE CAMPBELL COUNTY MARLS, CLAYS, AND SANDS, DRIED AT 212° F.

	No 1315	No 1316	No. 1317	No. 1318	No. 1319	No. 1320	No. 1321	No. 1322	No. 1323
Silica	47.320	68.760	58.080	51.420	72.660	82.560	57.160	81.660	85.840
Alumina, and oxides of iron and manganese	28.050	12.050	31.490	29.450	20.500	12.223	33.540	12.700	3.500
Lime, carbonate	13.490	9.860	.660	6.850	a trace.	.160	.860	a trace.	7.400
Magnesia, carbonate	1.135	3.859	1.135	1.256	.832	a trace.	1.776	a trace.	.296
Potash	3.254	1.329	3.045	4.124	1.243	.675	2.698	.756	not est.
Soda	.640	.976	.986	.567	not est.	.282	.555	.637	not est.
Phosphoric acid	.345	.223	.255	.122	.192	not est.	not est.	a trace.	not est.
Sulphuric acid	Not esti	mated.							
Water expelled at red heat	4.800	2.200	4.700	4.400	4.200	4.100	3.411	4.400	2.200
Loss	.966	.743	....	1.811	.373	....	....	....	.764
Total	100.000	100.000	100.351	100.000	100.000	100.000	100.000	100.153	100.000

These marly shales, marls and clays, are not especially valuable as fertilizers, although some of them contain considerable proportions of potash and phosphoric acid. The former, however, is mostly in firm combination in the silicates, which are insoluble in acids, so that it can only be made available by long weathering, or, possibly, by the action of lime, &c.

No. 1315 appears to be the best of them. They all would be useful as top-dressing for improving light sandy soil.

The sands have no peculiar interest, although useful for many well-known purposes.

No. 1324—SOIL. *Labeled "Virgin Soil, in open woods, farm of Gen. G. B. Hodge. Flat Woods; waters of Phillips' Creek; one and a half miles southeast from Grant's Lick. Timber—white oak, hickory, small beech, and walnut." Collected by Prof. N. S. Shaler.*

Soil of a warm yellowish-drab color. It all passed through the coarse sieve (of 289 meshes to the inch), except some

rootlets, a very small quantity of shot-iron ore, and a few small rounded pebbles of milky quartz.

No. 1325—SOIL. *Labeled "Old Field Soil. Field adjoining the woods whence came No. 1324. Cultivated in corn and tobacco for more than forty years. No manuring. Still brings a little corn. Sample one to seven inches from the surface." Collected by Prof. N. S. Shaler.*

Soil of a warm yellowish-drab color. All passed through the coarse sieve except a few fragments of wood, two or three small water-worn pebbles of milky quartz, and some small angular fragments of decomposing chert. It also contains some fine shot-iron ore.

No. 1326—SOIL. *Labeled "Same old field as the preceding. Plowed in* 1871 *to the depth of twenty inches and sub-soiled. Now* (1873) *in timothy grass. Seems to want lime." Collected by Prof. N. S. Shaler.*

Color, &c., much as in preceding soil.

No. 1327—SOIL. *Labeled "Sub-soil, twelve inches from the surface, same field as preceding, forty years in cultivation. Silicious mudstone beneath." Collected by Prof. N. S. Shaler.*

Soil of a yellowish-drab color; more yellowish than preceding. All of it passed through the coarse sieve, except a very small quantity of shot-iron ore.

No. 1328—SOIL. *Labeled "Spur of hill sixty feet above the position of the preceding soils. In corn for two years. Twenty bushels to the acre this year* (1873); *bad culture. Surface soil."*

Soil of drab color. Lighter colored than any of the preceding soils. Moist soil cakes in the bag like clay. It mostly passed through the coarse sieve, leaving only some shot-iron ore and small quartz pebbles, &c.

No. 1329—SOIL. *Labeled "Virgin Soil, border of cultivated field, newly cleared. Slope faces southwest. Land reputed rich; but in the midst of much poor land. Sells for two hundred dollars per acre. Youtsey's land, eight miles from Newport, Alexandria Turnpike." Collected by Prof. N. S. Shaler.*

A clay soil of a dark buff-grey color. Aggregated, on drying in the bag, &c., into quite hard, irregular and angular small lumps. Makes a very tenacious, sticky clay when wet.

No. 1330—SOIL. *Labeled "Sub-soil (under the preceding soil) two feet from the surface, &c." Collected by Prof. N. S. Shaler.*

A clay soil of a light grey-buff color; aggregating into pretty compact lumps on drying.

See No. 1334 for composition of the limestone underlying this land.

No. 1331—SOIL. *Labeled "A curious gravelly loam, two feet below surface, with bits of chert, from the sub-carboniferous of Upper Licking. Silicious mudstone and limestone below. Upper waters of Pond Creek, near Pond Creek Post-office, on new turnpike, about four miles southwest of Alexandria." Collected by Prof. N. S. Shaler.*

A deep yellow-buff colored sub-soil, containing nearly one sixteenth of its weight of fragments of ferruginous shaly sand rock, rounded quartzose pebbles, and shot-iron ore.

No. 1332—SOIL. *Labeled "Old field in grass. Slope of* 10° *south. Resting on river detritus. Side of run near Newport, Kentucky." Collected by Prof. N. S. Shaler.*

Soil of a dark grey-buff color. All of it passed through the coarse sieve.

No. 1333—SOIL. *Labeled "Bottom field of the next preceding, taken two feet from the surface. Detrital grit. Twenty feet above high water of Ohio river."*

Soil of a handsome orange-grey, or grey-orange-buff color. Aggregated into friable clods.

COMPOSITION OF THESE CAMPBELL COUNTY SOILS AND SUB-SOILS, DRIED AT 212° F.

	No. 1324	No. 1325	No. 1326	No. 1327	No. 1328	No. 1329	No. 1330	No. 1331	No. 1332	No. 1333
Extracted from 1,000 parts by carbonated water	2.290	1.700	1.220	0.830	1.860	2.700	5.650	0.716	1.080	1.200
COMPOSITION OF THE CARBONIC ACID WATER EXTRACT.										
Organic and volatile matters	1.060	1.030	0.580	0.530	0.720	0.690	0.490	0.316	0.396	0.815
Alumina, oxd. iron, &c.	.320	.130	.110	.040	.080	.020	.050	.010	.060	.030
Manganese oxide	.060	.070	.080	not est.	not est.	not est.	not est.	not est		
Lime, carbonate	.610	.400	.260	.090	.760	1.620	4.440	.180	.430	.280
Magnesia	.080	.036	.004	.040	.010	not est.	.450	.030	.010	.040
Nitric acid	Not estimated.									
Phosphoric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Chlorine	Not estimated.									
Potash	.060	.070	.050	.010	.050	.030	.020	.020	.037	.020
Soda	.010	.050	.040	.030	.020	.040	.020	.040	.015	.020
Soluble silica	.122	.090	.055	.150	.170	.070	.180	.130	.080	.067
Loss			.021		.050	.230			.052	
Total	2.322	1.876	1.220	0.890	1.860	2.700	5.650	0.726	1.080	1.272
COMPOSITION OF THESE SOILS, DRIED AT 212° F.										
Organic and volatile matters	3.650	2.555	2.540	2.435	8.965	7.615	5.960	5.160	2.775	2.135
Alumina	3.375	3.415	3.900	3.868	4.040	5.175	5.323	3.815	1.587	2.737
Iron oxide	3.125	3.038	3.274	3.972	4.787	6.750	6.890	4.300	2.980	4.465
Manganese, br. oxide	.059	.037	not est.	.427	.471	.260	.080	.390	.070	.320
Lime, carbonate	.130	.090	.125	.125	.450	.990	3.890	a trace.	a trace.	a trace.
Magnesia	.034	.496	.008	.250	.250	.520	.500	.474	.191	.300
Phosphoric acid	.145	.109	.093	.122	.093	.483	.313	.420	.256	.240
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash	.120	.062	.064	.062	.240	.726	.593	.443	.115	.125
Soda	.047	.132	.160	.109	.071	a trace.	.019	.045	.048	.106
Soluble silica*	.045	.090	.055	.015	.170	.070	.180	.130	.080	.067
Sand and insoluble silicates	87.545	89.335	88.395	87.560	78.963	75.590	75.415	83.775	91.655	89.040
Water expelled at 380° F.	1.160	1 110	1.020	1.040	1.500	1.850	1.017	1.250	1.035	1.010
Loss	.565		.366	.015						
Total	100.000	100.469	100.000	100.000	100.000	100.000	100.180	100.202	100.792	100.545
Water expelled at 212° F.	1.765	1.550	1.665	2.235	2.550	5.075	4.300	4.825	1.400	2.215
Potash in insolubie silicates	not est.	1.311	not est	1.477	not est.	2.731	not est.	not est	not est.	not est.
Soda	not est.	.700	not est.	.389	not est.	.929	not est.	not est.	not est.	not est.
Character of soil	Virgin soil.	Old field	Old field	Sub-soil.	New soil	Virgin soil.	Sub-soil.	Gravelly loam.	Old field	Old field

* It is proper to state, that this quantity does not represent the "soluble silica" which might have been extracted by boiling the "silicious residue" in solution of carbonate of soda, &c., but simply the amount which was held in the acid solution of the soil. But little importance was attached to this determination, not because its existence in the plant is considered by many modern agricultural chemists as "an accident" and "unessential," if not "useless" (see "How Crops Feed," by Prof. S. W. Johnson, page 353); but because it is to be found, ordinarily, dissolved in all waters which percolate soils. Moreover, Prof E. A. Hilgard shows that the amount of soluble silica in the silicious residue of a soil usually bears a pretty constant relation to the quantity of lime in it. Its proportion at any given time doubtless depends on the relative decomposition of the silicates of the soil at that time.

In addition to the determinations given in the preceding table of the composition of these soils, the "*sand and insoluble silicates*" were analyzed, by the method of fusion, &c., &c., with the following results, viz:

COMPOSITION OF THE SAND AND INSOLUBLE SILICATES IN THE 100 PARTS, DRIED AT 212° F.

	No. 1325.	No. 1327.	
Silica	89.560	88.660	
Alumina, &c., &c.	7.650		
Lime	.324	9.310	
Magnesia	.260		
Potash	1.464	1.684	= 1.311 and 1.477, severally calculated into 100 parts of the soil.
Soda	.743	.346	
Total	100.001	100.000	

An attempt was also made, with the use of the celebrated Nobel's apparatus, to submit some of these soils to silt analysis; *i. e.* to determine the relative proportions of the fine and coarser earthy material contained in them; but the results of comparative operations on the same soil were so discordant that no value whatever could be attached to them.

The writer regrets that he was not able, for want of time, &c., to apply to the silt analyses of some of these soils the improved apparatus devised by Prof. Eugene W. Hilgard, and used by him in his researches on the soils and clays of Mississippi, while he was the State Geologist, as described by him in a paper read by him at the Portland meeting of the *American Association for Advancement of Science*, August, 1873, and published in *American Journal of Science and Arts*, October and November, 1873.

The chemical analyses were conducted very much as is described in volume III of Kentucky Geological Reports, except that a larger quantity of the soil was digested in water containing carbonic acid, charged under the atmospheric pressure only, and found by analysis to contain about 0.9 of its volume of this gas. Instead of filtering the solution, a proportional quantity of it was drawn off from the residue by means of a pipette of proper construction.

The residue obtained by evaporating this solution, frequently *deflagrated* when ignited, showing the presence of *nitrates*.

This was observed, in a marked degree, with the extracts from Nos. 1324, 1325, 1326, 1327, and 1329.

The above table of the results of the analyses of these soils is interesting, as demonstrating, what has frequently been called in question by agricultural chemists in recent times, the possibility of ascertaining the agricultural capabilities of soils by chemical analysis; having due reference, of course, to the physical conditions.

For the purpose of more ready comparison of some of the results of these analyses, we copy in the following table the proportions of some of the most essential ingredients and educts of these soils:

	Extracted by carbonated water from 1,000 parts.	Extracted by acids from 100 parts.			
		Organic and volatile matters.	Lime, carbonate.	Phosphoric acid.	Potash.
No.					
1324, virgin soil	2.322	3.650	0.130	0.145	0.120
1325, old field, same locality. . .	1.876	2.550	.090	.109	.062
1326, old field, same locality . .	1.220	2.554	.125	.093	.064
1327, sub-soil, same locality . . .	.891	2.435	.125	.122	.062
1328, new field, same locality . .	1.860	8.965	.450	.093	.483
1329, virgin soil (Youtsey's), high priced; considered rich . .	2.700	7.615	.990	.483	.726

Youtsey's land will be seen, by reference to Appendix No. A. 12, to be strikingly like the California adobe soil in composition and consistence. It also resembles good blue grass soil. The others show a deficiency of lime, potash, and organic matters, or *humus*, except that of the "new field," which, like No. 1325, is apparently deficient in phosphoric acid, and which would be much more productive under better culture than it has received, and with the application of phosphate or superphosphate of lime. The use of lime, wood ashes, and of green crops, especially of clover, would be beneficial to these soils of Col. Hodges?

No. 1334—LIMESTONE. *Labeled "Blue Limestone (Cincinnati Group), just below soils Nos. 1329 and 1330. Youtsey's land, Alexandria Turnpike, eight miles from Newport, Campbell county." Collected by Prof. N. S. Shaler.*

A firm coarse-grained semi-crystalline, dark-grey limestone full of fossils, corals and shells, with some included nodules of light olive-grey granular material.

COMPOSITION DRIED AT 212° F.

Lime, carbonate	93.200 =	52.192 per cent. of lime.
Magnesia, carbonate	2.291	
Alumina, and iron and manganese oxides	1.700	
Sulphuric acid	.535 =	.214 per cent. of sulphur.
Phosphoric acid	.076 =	.033 per cent. of phosphorus.
Potash	.173	
Soda	.384	
Silex and insoluble silicates	2.360	
	100.719	

A limestone not very rich in mineral fertilizers, which would yield a good lime for building purposes.

No. 1335—"MARLY SHALE, *from two miles south of Newport, Licking Three Mile Creek. Geological position, 'Cincinnati Group,' fifty feet above high water mark of the Ohio river." Collected by Prof. N. S. Shaler.*

A friable shale of a handsome light olive-grey color, containing fragments of small encrinital stems and of *orthis multicoste.*

No. 1336—"MARLY SHALE, *from Licking Three Mile Creek, two miles back of Newport (Cincinnati Group). About sixty feet above high water mark of the Ohio river. The beds are about thirty feet thick, with thin partings, and can be easily stripped. Test their value as marl." Collected by Prof. N. S. Shaler.*

Of a light olive-grey color. The laminæ are thinner than in the preceding.

COMPOSITION OF THESE MARLY SHALES, DRIED AT 212° F.

	No. 1335.	No. 1336.
Silica	54.160	57.260
Alumina	12.269	16.782
Iron peroxide, with some manganese oxide	15.550	11.500
Lime, carbonate	7.800	4.560
Magnesia	.165	.778
Phosphoric acid	.281	.008
Sulphuric acid	.659	.233
Potash	3.298	4.471
Soda	.926	1.072
Water expelled at red heat and loss	4.892	3.336
Total	100.000	100.000

These marly shales resemble in composition the marls and clays reported above.

CARTER COUNTY.

No. 1337—CLAY. *Labeled "Fire-clay; average sample from the upper bed, four feet thick, on both sides of the hill. Ridge between Grassy and Three Prong Creeks, Boone Furnace property. Whole bed eight to ten feet thick. Collected by Philip N. Moore."*

The dried clay is quite compact, scarcely to be scratched with the nail; has a soapy feel; not adhering to the tongue. Breaks into sharp angular fragments. It is of a light-grey color.

No. 1338—CLAY. *"From ridge between Grassy and Three Prong Creeks, Boone Furnace property. Lower bed. Collected by P. N. Moore."*

Compact, breaking into sharp angular fragments; hardly to be scratched with the nail; slightly adhering to the tongue; has a somewhat soapy feel. Presents, in parts, an approach to an oölitic structure. Color dark-grey, passing into dove-color.

No. 1339—CLAY. *"From same locality as preceding. Rougher part of the upper layer, &c., &c. Collected by P. N. Moore."*

A light-grey compact rock, of a harsh gritty feel; not to be scratched with the nail. Under the glass showing many

rounded grains of quartzose sand. Ferruginous incrustation on the surface.

No. 1340—CLAY. *"Fire-clay under coal. Old Orchard Diggings, Boone Furnace property, Carter county. Collected by P. N. Moore."*

A compact shaly clay, with some of the lamellar surfaces polished in various planes. Has a soapy feel, and no grit. Of a dull dove-grey color.

No. 1341—CLAY. *"Fire-clay from same bed as Nos. 1337, 1338, and 1339. A dark-colored sample from the lower part of the deposit." Collected by P. N. Moore.*

Compact fine-granular; hardly scratched with the nail; adhering very slightly to the tongue. Of a dark brownish-slate color.

No. 1342—CLAY. *"Fire-clay under the twelve inch coal Geo. Osenton's land, near Grayson, Carter county. Sampled by J. A. Monroe."*

A grey or ash-grey clay in a pulverulent condition.

No. 1343—CLAY SHALE. *Labeled "Argillaceous Shale, with some Lingulæ near the top. Railroad cut, half mile south of Station (Eastern Kentucky Railroad), Grayson, Carter county. Collected by Prof. N. S. Shaler."*

A soft friable shale of a light buff-grey color, mottled and colored between the laminæ with ferruginous and black.

COMPOSITION OF THESE CLAYS, &c., OF CARTER COUNTY, DRIED AT 212° F.

	No 1337.	No. 1338.	No. 1339.	No. 1340.	No. 1341.	No. 1342	No. 1343.
Silica	48.560	45.960	54.620	62.460	45.560	64.260	66.060
Alumina	37.471	38.531	32.466	27.203	43.775	24.604	23.726
Iron, oxide	a trace.	a trace.	a trace.	a trace.	a trace.	not est.	not est.
Lime	.112	.145	a trace	a trace.	.145	.538	*.300
Magnesia	a trace.	a trace.	a trace.	a trace.	a trace.	.209	*.121
Phosphoric acid	.255	.563	.243	.147	.307	.946	.127
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	.157	not est.
Potash	.289	.250	.212	1.850	.963	.751	2.093
Soda	.283	.341	.679	.584	.728	.515	2.273
Water expelled at red heat	13.030	14.210	11.780	7.756	8.522	8.300	5.300
Total	100.000	100.000.	100.000	100.000	100.000	100.280	100.000

*Carbonates.

The composition of these clays indicate that most of them are highly "refractory" or fire-clays, and that all could be used for the manufacture of stone-ware, terra cotta, &c. Those which burn white might be used for "delf ware," or "queen's-ware," so called.

The most refractory are, probably, Nos. 1337, 1338, and 1339; the next, Nos. 1342, 1341, and 1340. The least refractory of all is the clay shale, No. 1343, which, however, notwithstanding its more than two per cent. each of potash and soda, would answer for the manufacture of stone-ware, and, most probably, of ordinary fire-brick.

It is found that a large relative proportion of silica or sand increases the refractory quality of the clay, and, according to the experiments of E. Richters* (1868), this quality is least affected by magnesia; more so by lime; still more by iron oxide; and most by potash. The influence of phosphates has not been fully determined.

For comparison, the analyses of two of the best Kaolin clays of France, of the best Stourbridge clay of England, and of a crucible clay, are here appended:

	(*a*)	(*b*)	(*c*)	(*d*)
Silica	48.68	55.30	63.40	47.50
Alumina	36.92	30.30	31.70	34.37
Iron oxide	. . . . .	2.00	3.00	1.24
Lime	not given.	not given	not given.	.50
Magnesia	.52	.40	not est.	1.00
Phosphoric acid	not given.			
Sulphuric acid	not given.			
Potash	not est.	1.10	1.90	not est.
Soda	.58	2.70		not est.
Water expelled at red heat	13.13	8.20	not given.	1.00

(*a*) Porcelain clay of Saint Yrieiex; analyzed by Forchammer.
(*b*) Porcelain clay of China; analyzed by Ebelmann and Salvetat.
(*c*) Stourbridge fire-clay: analyzed by Prof. F. A. Abels.
(*d*) Crucible clay. Almerode, in Kurhessen.

It is evident our fire-clays do not suffer in comparison with these, and that the industrial value of these large deposits in our coal measures is very considerable.

[For other fire-clays see Greenup county, &c.]

* R. Wagner's Chemical Technology, American edition, page 294.

COALS OF CARTER COUNTY.

No. 1344—"COAL, *probably sub-conglomerate, at Old Orchard Diggings. (Eight inches of coal, four inches of slate, six inches of coal.) Boone Furnace property.*"

A dull slaty coal, having much fibrous coal between the laminæ. Exterior stained with iron oxide.

No. 1345—"COAL, *No. 7, from old entry back of Star Furnace. Upper layer twenty inches thick (Coalton coal). An average sample, collected by A. R. Crandall.*"

Breaks easily into thin irregular laminæ, with some fibrous coal between. Incrusted somewhat with iron oxide.

No. 1346—"COAL, *No. 7, from old entry back of Star Furnace. Bottom layer, two feet two inches thick. Collected by A. R. Crandall.*"

A pure-looking coal; fracture glossy and pure black, somewhat like that of asphaltum. Very little fibrous coal, pyrites, or ferruginous incrustation apparent.

No. 1347—"COAL, *No. 7, from entry back of Star Furnace. Middle layer, two feet thick. Collected by A. R. Crandall.*"

Appears to be intermediate in quality to the two preceding.

No. 1348—"COAL, *No. 7 (Coalton). Average sample from Wiley Pritchard's bank, near Mount Savage Furnace, Carter county. Collected by J. A. Monroe.*"

No. 1349—"COAL, *No. 7. Average sample of the six feet Coalton coal, from all parts of the bed. Divide between Stinson and Straight Creeks. (Two hundred and seventy-five feet level.) Mount Savage property. Averaged by P. N. Moore.*"

No. 1350—"COALTON COAL (*No. 7 coal*), *from drift on Gum branch of Straight Creek. Mount Savage Company drift, lower part of the bed. Averaged by P. N. Moore.*"

No. 1351—"COALTON COAL (*No. 7 coal*), *from drift on Gum branch of Straight Creek. Upper part of bed, Mt. Savage property. Averaged by P. N. Moore.*"

No. 1352—"*Average sample of Coalton coal (No. 7), Watson Bank, Willard, Carter county. Averaged by J. A. Monroe.*"

No. 1353—"COAL (*No. 1*) *from Graham bank, Little Fork of Little Sandy river, near Willard. Average sample by P. N. Moore.*"

[See appendix, Nos. 1646 and 1647, for the analyses of two other samples of the coal from this bank.]

No. 1354—"COALTON COAL (*No. 7*), *from main entry, west of Dry Fork, Willard. Averaged by P. N. Moore.*"

A jet-black pure-looking coal, showing iridescent colors on portions, and having very little fibrous coal or pyrites.

No. 1355—"COALTON COAL (*No. 7*) *from Old Lost Creek drift, near Willard. Averaged by P. N. Moore.*"

Of rather a rusty black color; shows but little fibrous coal or ferruginous stain.

No. 1356—"COAL (*No. 2*) *from Kibby drift, Everman's Creek, two miles from Grayson, Carter county. Average sample by J. A. Monroe.*"

No. 1357—"COAL (*No. 1*) *from Stone-coal branch of Tygert Creek, Carter county. Averaged by P. N. Moore.*"

No. 1358—"COAL (*probably No. 2*) *from a quarter of a mile north of N. Lewis' house, Barrett's Creek, Carter county. Averaged by P. N. Moore.*"

No. 1359—"COAL (*probably No. 3*) *from Carter farm, two miles east of Grayson, on Dr. Jones' land (not a very good average sample). P. N. Moore.*"

COMPOSITION OF THESE CARTER COUNTY COALS, AIR DRIED.

	No. 1344	No. 1345	No. 1346	No. 1347	No. 1348	No. 1349	No. 1350	No. 1351	No. 1352	No. 1353	No. 1354	No. 1355	No. 1356	No. 1357	No. 1358	No. 1359
Specific gravity	1.330	1.377	1.288	1.290	1.435	1.347	1.340	1.323	1.326	1.274	1.352	1.337	1.289	1.298	1.307	1.388
Hygroscopic moisture	7.00	7.70	6.60	6.40	5.40	6.90	6.40	6.06	4.40	3.80	3.20	3.70	4.10	4.60	4.20	3.00
Volatile combustible matters	36.26	28.16	34.36	27.22	32.70	33.96	31 40	32.94	33.60	34.50	35.06	35.96	34.60	33.50	33.70	36.20
Coke	56.74	64.14	59.04	66.38	61.90	59.14	62.20	61.00	62.00	61.70	61.74	60.34	61.30	61.90	62.10	60.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	43.26	35.86	40.96	33.62	38.10	40.86	37.80	39.00	38.00	38.30	38.26	39.66	38.700	38.10	37.90	39.20
Carbon in the coke	44.64	53.04	54.64	58.88	52.52	51.04	57.66	54.80	52.86	58.50	54.40	52 94	56.525	51.60	51.40	49.24
Ashes	12.10	*11.10	†4.40	7.50	9 38	8.10	4.54	6.20	9.14	3.20	7.34	7.40	4.775	10.30	10.70	11.56
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.000	100.00	100.00	100.00
Character of the coke	Pulverulent.	Very friable.	Dense porous.	Very friable.	Dense porous.	Dense porous	Dense porous.	Dense porous.	Dense porous.	Dense porous.	Spongy.	Dense spongy.	Dense porous.	Dense porous.	Spongy.	Spongy.
Color of the ash	Nearly white.	Lilac-grey.	Light grey.	Light brown.	Lilac-grey.	Yellowish lilac grey.	Purplish grey.	Dark purplish grey.	Brownish-grey	Brownish-grey	Lilac-grey.	Grey-brown.	Lilac-grey.	Yellowish-grey	Brownish-grey	Lilac-grey.
Per centage of sulphur	not est	1.055	0.724	0.973	2.356	2.430	1.670	1.867	2.210	2.164	2.631	2.727	1.414	1.200	3.483	1.381

Composition of the ash of	* No. 1345	† No. 1346
Silica	5.38	2.00
Alumina and iron oxide	5.12	2.20
Lime, carbonate	0.32	a trace.
Loss	0.28	.20
Total	11.10	4.40

No. 1360—"COKE, *made from the No. 7 coal, in oven, by Mr. Bates, Willard, Carter county. Collected by A. R. Crandall.*"

A bright-looking coke somewhat dense.

COMPOSITION, AIR-DRIED.

Hygroscopic moisture	2.46
Volatile combustible matters	1.84
Coke (dry)	95.70
Total	100.00
Total volatile matters	4.30
Fixed carbon	87.34
Ashes	8.36
Total	100.00
Color of the ash	Lilac-grey.
Per centage of sulphur	2.026

The proportion of sulphur has been but slightly reduced by the coking of this coal. It is probably mostly in combination with iron, as iron proto-sulphide, and may not seriously injure this coke as fuel for the smelting and working of iron.

IRON CARBONATE ORES AND FERRUGINOUS LIMESTONE OF CARTER COUNTY.

No. 1361—FERRUGINOUS LIMESTONE. *Labeled "Limestone Ore, from Old Orchard Diggings, Boone Furnace property. Averaged by P. N. Moore."*

A dull-looking, fine-grained or compact ferruginous limestone, of a light-grey color, varied in parts by infiltrated hydrated oxide of iron. Fracture somewhat hackley. Specific gravity = 2.879.

No. 1362—CLAY IRON-STONE. *Labeled "Limestone Ore from drift at Old Orchard Diggings, head of Grassy Creek, Carter county. Undecomposed ore. Average sample from various parts of bed No. 1. Boone Furnace property. Collected by P. N. Moore."*

Irregular nodules and masses of clay iron-stone; varying in color from light-grey to blackish; mixed with some hydrated iron peroxide.

No. 1363—CLAY IRON-STONE. *Labeled "Kidneys in shale below the coal described, No. 1344, at Old Orchard Diggings, Boone Furnace property, &c. Shale, with the kidneys, four inches thick. Collected by P. N. Moore."*

Irregularly shaped nodules of fine-granular clay iron-stone superficially coated with hydrated brown iron oxide.

No. 1364—CLAY IRON-STONE. *Labeled "Limestone Ore (No. 1), Horsley bank, Boone Furnace property, &c. The undecomposed carbonate. Collected by P. N. Moore" (for a cabinet specimen).*

A fine-granular ore, varying from light-grey to purplish-grey, and incrusted in parts with limonite.

No. 1365—CLAY IRON-STONE AND LIMONITE MIXED. *Labeled "Average sample of Limestone Ore (No. 1), Horsley bank, Boone Furnace property, &c. Collected by P. N. Moore."*

A mixture of fragments of clay iron-stone and limonite ores.

No. 1366—CLAY IRON-STONE. *Labeled "Blue Limestone Ore, from west bank of Tygert Creek, about two miles from Iron Hills, Carter county. Average sample by P. N. Moore."*

Fragments of clay iron-stone nodules, invested externally with limonite layers.

No. 1367—CLAY IRON-STONE. *Labeled "Lower Block Ore, on Dry Fork of Sinking Creek, Carter county. J. M. James' land (six inches of undecomposed siderite). Average sample, by P. N. Moore."*

Compact clay iron-stone, with some little limonite.

No. 1368—CLAY IRON-STONE. *Labeled "Foxden Ore. Means and Russel land, Cumming's branch of Everman's Creek, Carter county. Averaged by P. N. Moore."*

The undecomposed carbonate covered with layers of limonite of various tints, some of which are ochreous.

No. 1369—CLAY IRON-STONE. *Labeled "Grey Limestone Ore, Mount Savage Furnace. Average sample, by J. A. Monroe."*

Grey granular and oölitic carbonate, with more or less limonite ore.

No. 1370—CLAY IRON-STONE. *Labeled "Lower Block Ore. Mr. Everman's Sammy's branch of Barrett's Creek, Carter county. Averaged by P. N. Moore."*

Mostly dark-grey, fine-granular carbonate ore, with some incrustation of limonite.

SUMMARY OF THE COMPOSITION OF THESE CARTER COUNTY CLAY-IRON-STONE ORES, &c., DRIED AT 212° F.

	No. 1361	No. 1362	No. 1363	No. 1364	No. 1365	No. 1366	No. 1367	No. 1368	No. 1369	No. 1370
Iron, carbonate	24.408	61.220	62.662	65.018	44.242	27.511	62.321	46.893	30.708	47.391
Iron, peroxide	. . . .	4.410	10.024	5.945	27.296	26.240	4.989	9.255	31.544	9.734
Alumina.	.560	2.260	1.600	1.060	1.500	9.021	7.901	5.703	1.779	4.197
Lime, carbonate	45.200	4.480	.240	2.720	6.580	2.320	12.000	12.460	2.730	5.220
Magnesia, carbonate . .	24.328	a trace.	2.838	9.038	1.046	2.838	.222	.250	.144	7.893
Manganese, carbonate .	.391	.150	3.251	2.332	.842	.270	.121	not est.	.060	.346
Phosphoric acid (anhydr.) .	.147	.313	.127	.255	.732	.499	.684	.978	.421	.121
Sulphuric acid (anhydr.)	.439	not est.	.521	1.280	4.587	.116	.206	a trace.	.491	.151
Silica and insol silicates	2.420	21.260	13.720	10.260	11.100	25.180	10.740	23 510	25.430	20.230
KO = .135; NaO = .204	= .339	.540	. . . .	2.112	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Water and loss.	1.768	5.367	3.017	. . . .	1.955	6.005	.816	.951	6.523	4.717
Total	100.00	100.000	100.00	100.000	100.000*	100.000	100.000	100.000	100.000	100.000
Per centage of iron. . .	10.960	32 578	37.285	35.549	40.465	31.598	33.348	29.116	36.627	29.685
Per ct. of phosphorus .	0.064	0.136	0.055	.111	.321	.208	.298	.427	.184	.052
Per centage of sulphur .	0.203	. . . .	.208	.533	1.855	.046	.082	. . . .	.196	.060
Per centage of silica . .	. . . .	. . . .	. . . .	. . . .	. . . .	23.80	8.980	20.860	10.560	19.760

* This sample had in it visible fragments of pyrites, and hence the above may not be an exact determination of the average sulphur of this ore.

No. 1361 would be unobjectionable as flux for richer ores, were it not for its considerable proportion of sulphur. It would make good lime for agricultural uses; which would make a strong cement with sand for all building purposes, where its color would not be objectionable.

The Horsley bank ores Nos. 1364 and 1365, although rich enough in iron, also contain quite large proportions of sul-

phur, exceeding in this respect all these ores; many of which may be considered quite good of their kind, as may be seen on examination of this table.

LIMONITE IRON ORES OF CARTER COUNTY.

No. 1371—LIMONITE. *Labeled "Limestone Ore from Horsley bank, Boone Furnace property. (A cabinet specimen.) Collected by P. N. Moore."*

In irregular curved laminæ of various tints, from dark brown to red and light yellow; with some soft ochreous ore.

No. 1372—LIMONITE. *Labeled "Average sample of Lambert Main Block Ore, Potato Knob Hill. From the stock pile, Iron Hills Furnace, Carter county. Collected by J. A. Monroe."*

Ore varying from dense dark chocolate-brown, irregular laminæ and grains, to brownish-yellow soft ochreous.

No. 1373—LIMONITE. *Labeled "Potato Knob Iron Ore. Average sample. Iron Hills Furnace, &c."*

In nodules varying from one to six inches in diameter. Exterior of hard dark-brown limonite; interior nodules soft and porous, of yellowish and reddish-brown colors.

No. 1374—LIMONITE. *Labeled "Main Block Ore, Stewart bank. Divide between Barrett's and Everman's Creeks, three miles west of Grayson, Carter county. Average sample."*

The irregular laminæ and concretions varying in color from dark chocolate-brown or purplish to greyish-yellow.

No. 1375—LIMONITE. *"From Royster Hill Lambert bed. Iron Hills Furnace. The ochre from the lower part of the bed."*

Porous and showing a small oölitic structure. Color brownish and greyish-yellow.

No. 1376—LIMONITE. *Labeled "German Ore. Smith. Hill. Taken from an imperfectly shown bed, possibly not fully representing the whole bed, except that the ore seems very uniform. None of the blue ore, or kidneys above the main bed, included in this sample. Iron Hills, Carter county. Collected by P. N. Moore."*

Ore generally porous or ochrey, of a yellowish-brown color mottled with light-grey. Some few laminæ of hard limonite.

No. 1377 — LIMONITE. *Labeled "Crown Ore. Smith Hill. Iron Hills, &c. Average sample, from upper part of the bed only, by P. N. Moore."*

Composed of irregular laminæ of dense dark-brown limonite, with cavities and included soft ochreous ore.

No. 1378—LIMONITE. *Labeled "Lower Block Ore. Perry's branch of Tygert Creek, west of Olive Hill. Land of Tygert Valley Iron Company. Average sample by P. N. Moore."*

Fragments of dense limonite laminæ mixed with some small clay iron-stone nodules.

No. 1379 — LIMONITE. *Labeled "Average sample of Lower Block Ore, from road on west side of Garvin's Hill, west of Olive Hill. Land of Tygert Valley Iron Company."*

Fragments of limonite laminæ and clay iron-stone nodules.

No. 1380—LIMONITE. *Labeled "Block Ore from Garvin's Hill, west of Olive Hill. Land of Tygert Valley Iron Company. Average sample."*

No. 1381—LIMONITE. *Labeled "Main Block Ore; Old Mount Tom Ore, Carter county. Averaged by J. A. Monroe."*

A very dense ore, in curved irregular laminæ of deep bluish and brownish colors, with some dark-brown softer ore between.

No. 1382—LIMONITE, *&c. "Main Block Ore with associated overlying Kidney Ore, from Kibby Diggings. Divide between Lost and Tygert Creeks. Carter county. Averaged by J. A. Monroe."*

Small nodules of fine-granular grey carbonate ore, surrounded by curved irregular laminæ of dense limonite, frequently separated by soft ochreous ore.

No. 1383—LIMONITE. *"Rough Ore, one hundred feet above the Foxden Ore (see clay iron-stones), on Means and Russel's land, Cumming's branch of Everman's Creek. Averaged by J. A. Monroe."*

In irregular hard thin laminæ of dark-brown to brownish-yellow colors; with some soft ochreous ore.

No. 1384 — LIMONITE. *"Red Limestone Ore from Graham bank. Average sample from the stock pile, by P. N. Moore."*

In curved, irregular, hard laminæ; varying in color from yellowish and reddish-brown to deep brown and almost black, with soft, lighter colored ochreous ore incrusting and included.

No. 1385—LIMONITE. *"Yellow Kidney Ore, Mount Savage Furnace, Carter county. Average sample, by P. N. Moore."*

In irregular curved laminæ, involving nuclei of softer ore. Color varying from deep brown and red to yellowish.

No. 1386 — LIMONITE. *"Main Block Ore, Stinson Creek. Mount Savage Furnace. Average sample, by J. A. Monroe."*

Curved irregular laminæ of dense limonite; generally dark colored, including light-grey nodules of porous carbonate of iron ore.

No. 1387 — LIMONITE. *"Ore seventy-three feet above the sub-carboniferous limestone. On Clark's branch of Tygert's Creek, two miles from Iron Hills Furnace. Average sample, by P. N. Moore."*

Varying from dense, dark-colored limonite laminæ to soft ochreous ore.

As will be seen, on examination of the following table of their composition, these limonite ores of Carter county are generally good, and may be profitably worked with proper management in the smelting; although some of them contain too much sulphur and phosphorus to make very tough iron.

COMPOSITION OF THESE CARTER COUNTY LIMONITES, DRIED AT 212° F.

	No. 1371	No. 1372	No. 1373	No. 1374	No 1375	No. 1376	No. 1377	No. 1378	No. 1379	No. 1380	No. 1381	No. 1382	No. 1383	No. 1384	No. 1385	No. 1386	No. 1387
Iron, peroxide	81.640	52.460	65.657	57.090	38.285	57.557	52 736	40.139	56.670	59.950	71.502	61.316	51.623	71.680	66.200	59.347	52.238
Iron, carbonate	....	....	....	....	....	....	....	5.731	8.538	....	....	19.435	....	....	....	9.599	....
Alumina	3.160	7.504	4.921	4.203	5.455	2.727	3.531	8.030	4.405	5.230	8.557	3.537	1.671	4.155	3.907	1.957	4.512
Manganese, brown oxide	a trace.	a trace.	a trace.	a trace.	.120	a trace.	.320	*.422	.180	....	a trace	a trace.	a trace.	.090	.030	.030	.130
Lime carbonate	.180	a trace.	a trace.	a trace.	.460	a trace.	a trace.	.380	a trace.	4.580	a trace.	a trace.	a trace.	.380	.430	830	.650
Magnesia	.919	.155	.040	.086	.065	.065	.065	*254	*.883	.343	.054	.212	.483	.050	.345	2.027	.641
Phosphoric acid	.060	1.224	.893	.370	1.000	1.746	.800	.038	.337	.842	.466	.166	.081	.084	.130	.153	1.695
Sulphuric acid	not est.	.268	.694	.391	.071	.185	.171	.177	.130	.845	.800	1.009	.408	.270	.182	.302	.230
Combined water	11.280	12.360	10.740	11.100	9.500	11.700	10.700	7.609	9.377	11.860	9.500	3.545	9.230	10.800	11.730	5.945	10.650
Silex and insoluble silicates	2.600	25.360	17.780	26.760	44.760	26.180	31.840	37.220	19.480	16.860	9.030	10.780	36.830	12.650	16.530	19.810	30.580
Moisture and loss	.161	.669	....		.284	....	....		....	....	.091		....	....	.633		
Total	100.000	100.000	100.635	100.000	100.000	100.760	100.103	100.000	100.000	100.510	100.000	100.000	100.326	100.159	100.000	100.000	100.119
Per cent. of iron	57.148	36.722	45.959	39.963	26.799	40.290	36.815	29.816	44.736	41.965	50.051	48.585	36.136	50.176	46.340	45.347	36.566
Per cent. of phosphorus	.026	.534	.391	.161	.436	.762	.344	.013	.147	.367	.203	.072	.035	.036	.057	.066	.740
Per cent. of sulphur	....	.107	.241	.156	.030	.074	.068	.071	.060	.335	.320	.403	.163	.108	.072	.120	.091
Per cent. of silica	not est.	23 980	15.960	22.256	40.960	not est.	27.360	....	....	16.860	7.640	9.960	....	11.560	13.860	15.060	24.260

*Carbonates.

55

LIMESTONES OF CARTER COUNTY.

No. 1388—"LIMESTONE *used as a flux at Boone Furnace when in operation. Collected by P. N. Moore.*"

A hard, compact, light buff-grey limestone. Fracture somewhat conchoidal.

No. 1389—"LIMESTONE (*sub-carboniferous*) *to be used as flux by the Iron Hills Furnace. Averaged by P. N. Moore.*"

A compact or fine granular limestone, of a light-grey color.

No. 1390—"LIMESTONE *used as flux at Mount Savage Furnace. Average sample, by J. A. Monroe.*"

A compact limestone of a dark-grey color, mixed with fragments of ferruginous sandstone and chert.

COMPOSITION OF THESE LIMESTONES, DRIED AT 212° F.

	No. 1388.	No. 1389.	No. 1390.
Specific gravity	2.624	2.700	not est.
Lime carbonate	97.720	95.150	75.750
Magnesia, carbonate	not est.	.245	.575
Alumina, and iron and manganese oxides	.300	1.390	6.403
Phosphoric acid (anhydrous)	.083	.130	.057
Sulphuric acid (anhydrous)	not est.	a trace.	.775
Potash	.115	not est.	not est.
Soda	.167	not est.	not est.
Silica and insoluble silicates	1.560	3.060	14.700
Soluble silica	.120	not est.	*1.740
Total	100.065	99.975	100.000
Per centage of lime	54.723	53.284	42.420
Per centage of phosphorus	.036	.056	.032
Per centage of sulphur	not est.	a trace.	.310

*Water and loss.

Nos. 1388 and 1389 are very pure limestones, and very suitable for use as flux in the iron furnace; but No. 1390 is quite objectionable, because of its considerable proportion of *sulphur*, and its nearly fifteen per centage of silicious matters.

PIG IRONS OF CARTER COUNTY.

No. 1391—PIG IRON. "*Foundry No. 2, made at Boone Furnace, Carter county, in* 1870."

A brilliant grey iron; moderately coarse-grained. Yields to the file; but breaks readily under the hammer.

No. 1392—PIG IRON. "*Foundry Iron No.* 1, *made at Boone Furnace in* 1870."

Darker colored, somewhat finer-grained, and softer than the preceding; flattening somewhat under the hammer.

No. 1393—PIG IRON. "*Hot Blast, No.* 1 *Foundry* ("*sow*"), *Iron Hills Furnace, Carter county. Collected by P. N. Moore.*"

Rather coarse-grained; with brilliant grains. Yields to the file, but is somewhat hard. Flattens but little under the hammer.

No. 1394—PIG IRON. "*Hot Blast, No.* 1 *Foundry, Mount Savage Furnace. Collected by P. N. Moore.*"

A brilliant coarse-grained iron. Hard, but yields to the file. Extends but little under the hammer.

	No. 1391.	No. 1392.	No. 1393.	No. 1394.
Specific gravity	6.423	6.905	7.021	6.889
Iron	90.958	93.212	92.387	91.502
Graphite	2.164	2.940	3.340	2.670
Combined carbon	.116	.060	.760	.030
Manganese	.115	.083	.056	.123
Silicon	2.682	1.634	2.240	4.470
Slag	4.180	2.460	.620	1.160
Aluminum	.479	.330	.120	.128
Calcium	not est.	not est.	.120	.144
Magnesium	.....	....	.056	.112
Potassium	....	.....	.080	.076
Sodium	.....	.....	....	.023
Phosphorus	.304	.486	.836	.203
Sulphur	not est.	.079	.057	.041
Total	100.998	101.284	100.672	100.680
Total carbon	2.280	3.000	4.100	2.700

SOILS OF CARTER COUNTY.

No. 1395—SOIL. *"From the farm of Jas. W. Scott, near Lower Tygert bridge, near Olive Hill, Carter county. Top soil in oak woods, sixty feet above the bed of the creek. Limestone slope southward. Drainage between the slope and the sandstone capping the hills. Sample to depth of six inches. Collected by Prof. N. S. Shaler."*

Virgin soil. Soil of a greyish orange-buff color, with streaks and mottlings of dark-grey. Compacted into clods in the bag. The coarse sieve (289 meshes to inch) removed about six per cent. of ferruginous and decomposing cherty fragments.

No. 1396—SOIL. *Labeled "Sub-soil of the preceding, one foot below the surface, &c."*

This sub-soil is of an orange-red, or bright red ochre color. Compacted into clods in the bag.

The coarse sieve removed from it a very small quantity of small fragments of weathered chert, &c.

No. 1397—"SOIL *from the farm of Jas. W. Scott (locality as above). Old field, in pasture for eighteen, and cultivated for five years. Slope from height of limestone bench and sandstone beyond. Northern exposure, thirty feet above Tygert Creek. Collected by N. S. Shaler."*

Soil of a dirty-grey buff color. Sifted out about five per cent. of cherty and ferruginous small fragments, with the coarse sieve.

No. 1398—"SUB-SOIL *of the next preceding, one foot below the surface, &c."*

Sub-soil colored like next preceding; slightly more reddish. Sifted out, with the coarse sieve, about twenty-three per cent of small fragments, more or less rounded, of ferruginous sandstone, iron ore, and weathered chert.

No. 1399—"Top Soil. *Woods near Iron Hill, Carter county. From eastward slope, ravine to southward. Limestone above, twenty-five feet thick. Conglomerate still above. Oak and beech woods, about one hundred feet above Tygert Creek. Collected by J. A. Monroe.*"

Soil of a grey-buff color. Sifted out, with the coarse sieve, about sixteen per cent. of shaly ferruginous sandstone fragments.

No. 1400—"Sub-soil *of the next preceding, taken eighteen inches below the surface, &c., &c.*"

Sub-soil of a lighter color than the surface soil and more adhesive. Contains fragments of sandstone.

No. 1401—"Top Soil, *for six inches below the surface, from an old field on Riggs' farm at Iron Hills. From the slope of hill toward Tygert Creek. Limestone one hundred feet or more above, and sandstone above that. Woodland a few rods off to top of the hill. This field has been cultivated in corn for many years.*" *Collected by J. A. Monroe.*

Soil of a grey-buff color. Sifted out of it, with the coarse sieve, about twenty per cent of fragments of ferruginous sandstone, &c.

No. 1402—"Sub-soil *of the next preceding, taken eighteen inches from the surface, &c., &c.*"

Of a handsome yellowish-buff color. Compacted into friable lumps in the bag. Sifted out, with the coarse sieve, about ten per cent. of fragments of ferruginous sandstone and iron ore.

No. 1403—"Surface Soil, *from woodland on farm of William Abbott, five miles west of Olive Hill, Carter county. One hundred and fifteen feet above the west branch of Tygert's Creek. Slope northwest. Limestone on top of the hill. Collected by A. R. Crandall.*"

Soil of a grey-buff color. The coarse sieve removed a considerable quantity of small ferruginous and cherty fragments.

No. 1404—"SUB-SOIL *of the next preceding. One foot from the surface, &c., &c. Collected by A. R. Crandall.*"

Of a buff color. Contains angular fragments of ferruginous sandstone.

No. 1405—"OLD FIELD SOIL. *Farm of William Abbott, west branch of Tygert's Creek, &c. Field fifty-five feet above the bed of the creek; on bench of Waverly sandstone. Tops of the hills capped with limestone. Surface soil; has been cultivated sixty years; was once an orchard.*" *Collected by A. R. Crandall.*

Soil of a light grey-buff color; aggregated into friable clods in the bag. The coarse sieve removed from it less than two per cent. of small silicious sandstone, cherty, and ferruginous fragments.

No. 1406—"SUB-SOIL *of the next preceding; one foot below the surface, &c.*" *Collected by A. R. Crandall.*

Sub-soil of a lighter and more clear buff color than the surface soil; contains less than two per cent. of small cherty and ferruginous gravel.

No. 1407—SOIL *from an old field on Widow Garvin's farm, four miles west of Olive Hill. Ten feet above the bed of Tygert's Creek. On Waverly sandstone; with limestone and coarse sandstone near the tops of the hills. Surface soil. Collected by A. R. Crandall.*"

Soil of a grey-buff color, contains about four per cent. of small rounded ferruginous sandstone and cherty fragments.

No. 1408—"SUB-SOIL *of the next preceding, one foot to eighteen inches below the surface. Collected by A. R. Crandall.*"

Sub-soil of a lighter color than the preceding surface soil; in friable clods.

Sifted out, with coarse sieve, about eight per cent. of ferruginous, cherty, and sandstone fragments.

No. 1409 — SOIL. *Labeled "Sub-soil of bottom land, two feet from the surface; twenty-five feet above Little Sandy river, Grayson, Carter county. The surface soil was not collected on account of accidents affecting its composition." Collected by Prof. N. S. Shaler.*

Sub-soil of a light buff-grey color; nearly white; in friable lumps. Seems to be mainly composed of fine grains of sand.

COMPOSITION, DRIED AT 212° F.

Volatile and combustible matters, expelled at red heat	2.500	
Alumina, and iron and manganese oxides	11.500	
Lime carbonate	.560	= .313 per cent. of lime.
Magnesia	.121	
Phosphoric acid	.223	
Sulphuric acid	not est.	
Potash (total obtained by fusion)	.366	
Soda (total obtained by fusion)	.587	
Silica (separated by fusion)	84.000	
Loss	.143	
	100.000	

This sub-soil having been analyzed by fusion with the mixed alkaline carbonates, and not by digestion in chlorohydric acid, as the other soils of this county were treated, could not be tabulated with them.

The proportions of potash and soda given above appear large, as compared with those found in similar sandy soils by digestion in acids; but these represent the *total amount* of these alkalies, contained not only in the soluble portion of the soil, but also in the insoluble silicates; the process of J. Lawrence Smith for the separation of the alkalies from silicates, viz: fusion with a mixture of lime carbonate and ammonium chloride, having been employed in the above analysis.

COMPOSITION OF THESE CARTER COUNTY SOILS AND SUB-SOILS, DRIED AT 212° F.

Extracted from 1000 parts of the air-dried soil, by digestion in water containing carbonic acid in solution.

	No. 1395.	No. 1396.	No. 1397.	No. 1398.	No. 1399.	No. 1400.	No. 1401.	No. 1402.	No. 1405.	No. 1406.	No. 1407.
Organic and volatile matters	0.500	0.420	0.500	0.370	lost.	0.350	1.120	0.320	0.700	0.340	0.800
Alumina, oxide of iron, and phosphoric acid	.030	.010	.010	.010	lost.	.020	lost.	.020	lost.	.020	.070
Brown oxide of manganese	.050	.010	.080	.030	lost.	.030	lost.	.020	lost.	.020	.290
Lime carbonate	.710	.130	.660	.330	lost.	.300	lost.	.060	lost.	.040	.720
Magnesia	.040	.010	.050	.020	lost.	.020	lost.	.030	lost.	.020	.100
Phosphoric acid	not est.	not est.	not est.	not est.	lost.	not est.	lost.	not est.	lost.	not est.	not est.
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	lost.	a trace.	lost.	a trace.	lost.	a trace.	a trace.
Chorine	a trace.	a trace.	a trace.	a trace.	lost.	a trace.	lost.	a trace.	a trace.	a trace.	a trace.
Nitric acid	not est.	not est.	not est.	not est.	lost.	not est.	lost.	not est.	lost.	not est.	not est.
Potash	.060	.060	.090	.050	lost.	.040	lost.	.040	lost.	.050	.050
Soda	.050	.030	.030	.040	lost.	.010	lost.	a trace.	lost.	.020	.020
Soluble silica	.070	.080	.110	.050	lost.	.030	lost.	.020	.030	.030	.020
Loss	.090	. . . .	.130	.120	lost.	.020	lost.	.060	lost.	. . . .	. . . .
Total extract, dried at 212° F.	1.600	0.770	1.660	1.020	. . . .	0.820	2.870	0.570	1.180	0.540	2.070
Color of extract	Dark brown.	Brownish white.	Dark umber.	Brownish grey.	. . . .	Yellow-ish-white	Umber (dark).	Yellow-ish-white	Brownish white.	Brownish white.	Dark umber.

GENERAL COMPOSITION OF THESE CARTER COUNTY SOILS, DRIED AT 212° F.

	No. 1395.	No. 1396.	No. 1397.	No. 1398.	No. 1399.	No. 1400.	No. 1401.	No. 1402.	No. 1403.	No. 1404.	No. 1405.	No. 1406.	No. 1407.	No. 1408.
Organic and vol. matters.	3.110	4.800	2.250	1.815	4.165	2.200	3.925	2.315	4.685	2.625	2.860	2.000	3.740	2.200
Alumina Iron peroxide Manganese, brown oxide	7.405	17.360	4.777	6.409	7.595	8.406	6.637	8.375	4.013	5.410	4.540	5.890	6.115	5.600
Lime carbonate	.420	.270	.880	.680	.320	.155	.180	.095	.109	.109	.145	.080	.245	.220
Magnesia	.272	.124	.057	.155	.088	.142	.051	.153	.050	.061	.035	.056	.115	.178
Phosphoric acid	.060	.045	.093	.076	.160	.109	.118	.115	.147	.163	.125	.163	.076	.086
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	.060	.046	not est.	not est.	not est.	not est.
Potash	.293	.662	.213	.255	.275	.385	.279	.273	.153	.371	.111	.204	.279	.366
Soda	.148	.149	.132	.151	.186	.169	.163	.076	.032	.046	.157	.131	.286	.048
Soluble silica	.170	.095	not est.	.145	.245	.160	.145	.145	not est.	not est.	.220	.020	.220	.120
Sand and insol'ble silicates	87.630	74.840	91.690	90.515	85.465	87.340	88.140	87 740	89.515	89.940	91.240	91 575	89.390	91.255
Water expelled at 380° F.	.885	1.400	.600	.480	1.160	.625	.900	.555	.990	.770	.690	.450	.828	.450
Loss	. . . . .	.255	. . . . .	. . . . .	.341	.309	. . . . .	.158	.246	.459	. . . . .	. . . . .	. . . . .	. . . . .
Total	100.393	100.000	100.692	100.681	100.000	100.000	100.538	100.000	100.000	100.000	100.123	100.569	101.294	100.483
Moisture lost at 212° F.	2.020	2.354	1.125	1.270	1.945	1.400	1.475	1.405	1.380	1.270	1.215	1.275	1.350	1.035
Potash in insol'ble silicates	.584	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Soda in insoluble silicates	.165	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Character of soil	Virgin soil	Sub-soil.	Old field.	Sub-soil.	Virgin soil	Sub-soil.	Old field.	Sub-soil.	Virgin soil	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.

63

Although these Carter county soils cannot be classed with the naturally very rich soils, there is no apparent reason, in view of their composition, why they may not be made quite profitably productive, under proper culture and by the observance of the golden rule of agriculture viz: to restore to the soil in manures, &c., the essential ingredients which are removed from it in the crops. These soils are measurably deficient in *humus* or organic matters, and contain rather more than the normal proportion of sand and silicates. These defects may be remedied in some localities, where the sub-soil contains more clay, &c. (as is the case with No. 1396), by gradually bringing up the sub-soil, in the annual plowings, with the simultaneous use of clover and other green crops. It appears also from the analyses, that while lime and potash seem to be in sufficient abundance, phosphoric acid is rather deficient in most of these soils. The use of bone-dust, or other phosphatic fertilizers, would doubtless be beneficial.

The influence of cropping on the composition of the soil may be measurably observed by comparing the analyses of the virgin soils and the old field soils, as given above. In all the proportion of organic matters is found to be reduced, and that of the sand and silicates increased, in the old field, as compared with the virgin soil; and in most of them a reduction in quantity may be seen in the potash and phosphoric acid of the old field; showing the exhausting influence of cropping without the use of manures.

EDMONSON COUNTY.

No. 1410—LIMONITE. *Labeled "From Bythe Meredith farm. Collected by Prof. N. S. Shaler (Nolin)."*

Composed partly of elliptical hollow concretions of dense dark reddish-brown laminæ, with some softer ochreous ore.

No. 1411—LIMONITE. *Labeled "Proctor Ore Bank, Sycamore Creek. Collected by Prof. N. S. Shaler and J. R. Proctor."*

Principally in dark brown dense laminæ, forming an irregular stalactitic, hollow columnar structure with septæ (or irregularly

large cancellated), incrusted with some softer yellowish and brownish ochreous ore.

No. 1412—LIMONITE. *Labeled "Frederick's Bank, Beaver Dam Creek. Two hundred feet above the limestone. Collected by Prof. N. S. Shaler. (Five feet ore. Uniform.")*

Generally of a yellowish-brown color, porous and cellular; but with some dark hard laminæ, small whitish oölitic concretions some of which are hollow, and brownish and yellowish ochreous material. Contains some fossil shells, &c.

COMPOSITION OF THESE EDMONSON COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1410.	No. 1411.	No. 1412.
Iron, peroxide	55.028	76.284	52.926
Alumina	1.006	2.361	4.792
Manganese, brown oxide	.040	.030	.210
Lime carbonate	a trace	.180	.180
Magnesia	.108	.068	.425
Phosphoric acid	.312	1.055	.355
Sulphuric acid	.133	.151	.143
Water expelled at red heat	8.300	12.000	10.400
Silex and insoluble silicates	35.180	7.951	30.580
Total	100.107	100.080	100.011
Iron, per centage	35.519	53.399	37.048
Phosphorus, per centage	.135	.460	.154
Sulphur, per centage	.053	.059	.057
Silica, per centage	33.700	7.660	29.160

These are good iron ores. No. 1411 is more than usually rich in iron, but it contains more phosphorus than is desirable.

[See Appendix for other iron ores of this county.]

No. 1413—COAL. *"From Tar Lick, Davis Creek, Edmonson county. Five and a half feet thick. Collected by Prof. N. S. Shaler."*

A glossy splint coal, breaking into thin irregular laminæ, with tar (petroleum) and fibrous coal—the remains of reedy leaves—and more or less fine-granular pyrites between them.

No. 1414—COAL. "*Found on Mill branch. Level of main Nolin coal. Collected by Prof. N. S. Shaler.*"

Splint coal. Separates under the hammer into thin irregular laminæ, with fibrous coal, containing fine-granular pyrites between.

No. 1415—COAL. "*Found on the surface. Has been longer exposed and more weathered than the preceding. Mill branch. Collected by Prof. N. S. Shaler.*"

No. 1416—COAL. "*From Knob Lick, Dismal Creek. Geological level of main Nolin coal. Collected by Prof. N. S. Shaler.*"

A weathered specimen of splint coal, incrusted with ochreous iron oxide on the surface. Separating into thin irregular laminæ, with fibrous coal between.

No. 1417—COAL "*At Gross', one hundred and eighty feet above Bear Creek. Collected by Prof. N. S. Shaler and J. R. Proctor.*"

A splint coal, breaking into thin irregular laminæ, with fibrous coal and much fine-granular pyrites between.

No. 1418—COAL. "*Shoal branch, Nolin coal. Collected by Prof. N. S. Shaler and J. R. Proctor.*"

Splint coal, breaking into thin laminæ, with fibrous coal and but little pyrites between them.

No. 1419—COAL. "*Tar Lick Coal, branch of Davis. (Main Nolin coal.) Collected by J. R. Proctor. Five and a half feet thick.*"

A deep-black coal, with soft bituminous matter between the thin laminæ, and but little fibrous coal or pyrites.

No. 1420—Coal. *"From Mill branch of Bear Creek. Average sample, by P. N. Moore."*

Much of it breaks into thin laminæ, with but little fibrous coal, and some fine-granular pyrites between.

COMPOSITION OF THESE EDMONSON COUNTY COALS, DRIED AT 212° F.

	No. 1413	No. 1414	No. 1415	No. 1416	No. 1417	No. 1418	No. 1419	No. 1420
Specific gravity	1.282	1.350	1.367	1.345	1.429	1.336	1.335	1.437
Hygroscopic moisture	2.30	3.60	3.20	2.60	1.20	3.66	4.06	4.06
Volatile combustible matters	32.10	33.00	33.80	33.80	39.00	35.14	33.24	32.00
Coke	65.60	63.40	63.00	63.60	59.80	61.20	62.70	63.94
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.40	36.60	37.00	36.40	40.20	38.80	37.30	36.06
Fixed carbon in the coke	56.30	54.40	52.60	53.14	45.46	54.26	51.70	50.84
Ashes	9.30	9.00	10.40	10.46	14.34	6.94	11.00	13.10
Total	100.00	100 00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Cellular.	Spongy.	Moderately dense.	Spongy.	Dense.	Light cellular.	Spongy.	Light spongy.
Color of the ash	Light lilac-grey	Lilac-grey.	Lilac-grey.	Light-grey.	Dark greyish-purple.	Lilac-grey.	Light lilac-grey.	Grey-lilac.
Per centage of sulphur	1.059	2.101	2.923	2.425	8.685	2.706	1.670	4.938
Per centage of phosphoric acid	not est.	not est.	not est.	not est.	0.178	not est.	not est.	not est.

These Edmonson county coals answer very well for the ordinary purposes of fuel, and those which do not contain an inordinate quantity of sulphur will doubtless answer well for the working of iron. No. 1417, however, contains more than eight per cent. of this ingredient, and more than fourteen per cent. of ashes, containing a notable proportion of phosphoric acid. Yet even this impure coal contains more than eighty-four per cent. of combustible matters, including part of the sulphur (some of which, however, remains in the ashes combined with iron), and may answer for ordinary fuel.

[For other Edmonson county ores, see Appendix.]

Cast Iron from Baker Furnace. Some fragments from this old furnace, which had been exposed to the weather for twenty

years, were collected by Prof. Shaler, for examination of its general quality.

It is a fine-grained, light-grey iron, which is more tenacious and extends more under the hammer than most samples of best pig iron. Possibly it has been improved in this respect by its long weathering in thin pieces. The analysis of a piece of the pig iron from this furnace will be found in the Appendix.

[For Nos. 1421, 1422, and 1423, see Barren county.]

FAYETTE COUNTY.

No. 1424—"SURFACE SOIL *to depth of one foot, of a field which has not been very long in cultivation, principally in hemp, of which it no longer produces very good crops. Blue-grass land, seven miles from Lexington on the Newtown Turnpike. Sub-stratum, Lower Silurian blue limestone. Land of E. M. Coleman.*" *Why is it not very good hemp land?*

Soil of a light greyish-brown color. It all passed through the coarse sieve, of 289 meshes to inch, except a small proportion of shot-iron ore and irregular fragments of chert.

No. 1425—"SOIL *to the depth of four inches from an old field fifty years or more in cultivation almost without intermission, without manure of any kind, principally in hemp and corn, with occasionally small grain. Farm of R. Peter, formerly of the late Col. S. Meredith, on the Newtown road, six and a half miles from Lexington; blue-grass land. Sub-stratum, blue limestone of the Lower Silurian formation.*"

Soil of a warm grey-brown color; containing only a few small angular fragments of weathered and porous chert.

This field was selected by my son, Benj. D. Peter, for some experimental agricultural operations, which he has reported to Prof. Shaler.

COMPOSITION OF THESE FAYETTE COUNTY SOILS, DRIED AT 212° F.

	No. 1424.	No. 1425.
Organic and volatile matters	6.340	6.575
Alumina, and iron and manganese oxides	8.890	8.200
Lime carbonate	.745	.440
Magnesia	.366	.221
Phosphoric acid	.550	.316
Sulphuric acid	.065	.036
Potash	.169	.247
Soda	.057	.263
Sand and insoluble silicates	81.467	83.340
Water and loss	1.556	.362
Total	100.000	100.000
Potash in the insoluble silicates	0.905	1.256
Soda in the insoluble silicates	.844	.101

The apparent paucity of potash in No. 1424 may account for its failure to produce good hemp crops.

As compared with the original virgin soil of the same locality, these soils contain much less *organic matters* (*humus*), and a smaller amount of *potash*, than that. These essential materials are especially influential in hemp production, as the presence of these and of lime seems to be necessary to a *vigorous* growth of this plant; the only kind of growth considered profitable by our farmers.

The current belief amongst our hemp-growers is, or has been, that this crop does not rapidly exhaust the soil, provided the hemp is spread for rotting on the field which produced it.

The rotting process does undoubtedly restore to the soil, in an available condition for plant nourishment, a considerable proportion of the fertilizing principles which had been withdrawn from it in the crop; but in the operation of braking the hemp, the hemp herds and rough tow being generally burnt on the spots where the process is performed, the alkaline and earthy ingredients of these become irregularly deposited, and much of the soluble fertilizing mineral matter of the ashes is liable to be washed down into the sub-soil, to become for the time unavailable; while a large quantity of vegetable matter,

which ought to be employed in returning to the soil the *humus*, which has been destroyed during the growth of the crop, is converted into atmospheric gases by burning.

The adoption of some plan by which our hemp-raisers may restore the organic matter of the hemp herds, &c., to the soil, in the form of *humus*, would tend to retard the exhaustion of the hemp land. But there exists a prejudice among them that hemp herds are injurious to the land, which is probably not based upon fact.

The *insoluble silicates* left after thorough digestion of these soils in warm chlorohydric acid assisted by a little nitric acid, was found upon analysis by fusion, to contain quite a large proportion of alkalies. In both cases these silicates contained *about five times as much potash* as was dissolved out from the soils by the acids. This quantity of the alkalies, in combination in the *insoluble silicates*, so-called, is not *immediately available* for plant nourishment, but yet serves to prolong the fertility of the soil; for these silicates, although not easily decomposable by acids, are gradually decomposed by the atmospheric agencies, and especially under the influence of alkaline substances.

Hence the application of lime, for instance, to soil of this kind, which has been measurably exhausted of its immediately available alkalies, may, by partial decomposition of these silicates, bring more of these alkalies into a soluble condition, and thus temporarily increase its fertility.

These insoluble silicates, left after the acid digestion, when examined with the lens, exhibit small grains, which look like partly decomposed feldspathic mineral, sometimes of different tints, mixed with minute rounded or angular grains of hyaline and milky quartz, &c.

These facts, especially that of the existence of so much potash and soda in these insoluble silicates of the soil, throw some light on the origin of soils; as they tend also to aid us in scientific agriculture.

No. 1426—QUICKLIME, *obtained by the calcination of limestone of some of the fossiliferous layers of the blue limestone of the Lower Silurian formation. Cliff on Elkhorn Creek, northeast boundary of the above named farm. Also some milky calcareous spar, from a four to six feet wide vein at the same locality, which was mixed and calcined with the limestone.*

This lime, not perfectly calcined, was used on the experimental field above mentioned.

Its *composition* was found to be as follows:

Lime	68.804
Magnesia	.241
Alumina, and iron and manganese oxides	4.565
Phosphoric acid	.415
Sulphuric acid	.446
Carbonic acid	11.450
Potash	1.330
Soda	.099
Silex and insoluble silicates	6.130
Water and loss	6.520
Total	100.000

This lime was not submitted to analysis until after it had been exposed to the air for a few days.

It will be seen from this analysis, that lime from these fossiliferous layers of our limestone may prove a valuable fertilizer, on fields which have been impoverished by too much cropping. For, not only will it, by its decomposing action on the insoluble silicates, render a new quantity of alkalies available for plant food, but its own considerable proportions of phosphoric and sulphuric* acids, and of potash and soda, will greatly aid in the amelioration.

No. 1426—CALCAREOUS SPAR (*above mentioned*) *from the vein, nearly vertical, in the blue limestone on North Elkhorn Creek, land lately belonging to R. J. Breckinridge's estate (Bradalbane).*

Analyzed by my son, Alfred M. Peter, as was also the quicklime.

* The considerable proportion of sulphuric acid given in the preceding analysis is probably partly derived from iron sulphids sometimes diffused in this limestone.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	96.610	= 54.101 per cent. of lime.
Magnesia, carbonate	.401	
Alumina, and iron and manganese oxides	1.740	
Phosphoric acid	.057	
Sulphuric acid	not est.	
Potash	.443	
Soda	.275	
Silica and insoluble silicates	.360	
Loss	.114	
	100.000	

This nearly opaque, milky calc. spar is much stained superficially with iron oxide, &c. The analysis shows a much smaller amount of phosphoric acid than is contained in the limestone layers; but the proportion of alkalies, if no error is made, is quite considerable.

WATERS OF FAYETTE COUNTY.

As is well known, the spring and well waters of this blue limestone region are what are denominated "hard waters," containing a considerable quantity of dissolved carbonates of lime and magnesia, &c.

As a type of these limestone waters, that of a remarkable spring, the "Big Spring," on the writer's farm, about six and a half miles from Lexington, on the Newtown Turnpike, was selected for chemical analysis.

This "Big Spring" is a perennial stream of considerable force, boiling up in the bottom of a sink-hole, which is some fifty to sixty feet deep; and flowing through underground channels and caverns a considerable distance, to be discharged into the North Elkhorn Creek.

The water was taken after the long dry season of our late summer and autumn, and was remarkably clear; as it always is except after heavy rains. The temperature of it was noted during one of our late protracted cold spells; and when the temperature of the atmosphere was at zero and only ten degrees above, it maintained that of fifty-three or fifty-four; very little below the mean of the temperature of this region.

The analyses of this water and of the waters of the bored wells given below, were made by my youngest son Alfred

Meredith Peter, under my inspection, as a chemical exercise, and were very carefully and faithfully performed.

The results show that the hard waters of our springs and wells might not only be fertilizers, when used for irrigating growing crops, but that, as was first noted by the celebrated Boussingault, they may supply to growing animals necessary earthy salts which may be deficient in their food. That, especially, they may supply lime to animals fed on Indian corn, which food is found to be somewhat deficient in this ingredient.

COMPOSITION OF THE BIG SPRING WATER IN 1000 PARTS.

No. 1427.	Held in solution by free carbonic acid.
Lime, carbonate	0.2027
Magnesia, carbonate	.0227
Iron, carbonate	.0027
Manganese, carbonate	.0003
Alumina	.0012
Phosphoric acid	.0001
Silica	.0011
Total of sediment formed on boiling	0.2308
	Contained in the boiled water.
Lime, sulphate	0.0208
Potassium, chloride	.0012
Sodium, chloride	.0018
Magnesium, chloride	.0027
Silica	.0074
Organic matters	.0086
Lithia	a trace.
Total saline matters	0.2733

The total saline matters amount to about sixteen grains to the wine gallon of water. They are doubtless derived from the soil and the limestone rock.

As was stated in the previous volumes of Kentucky Geological Reports, the water obtained in this region by boring into the limestone substratum is always more or less salt, and is frequently accompanied with gas (carburetted hydrogen), the flow of which, however, is not very durable. During the late very dry season a number of borings were made in this neighborhood (near Lexington), with the same results; the water smelling strongly of petroleum, and sometimes of sulphuretted hydrogen, being always more or less brackish, and there being generally a temporary emission of gas.

The waters of three of these bored wells were analyzed by my son (A. M. Peter), with the following results, viz:

No. 1428—"WATER *from a bored well of Mr. Sutton's, about ninety-eight feet deep, on the Leestown road, near the Scott county line.*"

A weak sulphur water.

No. 1429—"WATER *from a bored well of Mr. Edward P. Gains, about one hundred feet deep, on the Georgetown Turnpike, about nine miles northwest of Lexington, near Donerail.*"

The water rose about thirty feet in the well. Specific gravity = 1.035.

No. 1430—"WATER *from a bored well, about ninety-six feet deep, on the farm of Mr. Price McGrath, two and a half miles from Lexington, on the Newtown Turnpike.*"

The water rose to within about twenty-eight feet of surface. Gas was evolved in considerable quantities during the boring.

COMPOSITION OF THESE WELL WATERS.

Held in solution by free carbonic acid.

	No. 1428.	No. 1429.	No. 1430.
Lime, carbonate	0.1008	0.0104	0.1711
Magnesia, carbonate	.0882	.0018	.0053
Iron, carbonate	.0042	.0008	.0062
Manganese, carbonate	.....	.....	.0005
Phosphoric acid	a trace.	.....	.0002
Silica	.0078	.0038	.0017
Total sediment on boiling	0.2010	0.0168	0.1850

In solution in the boiled water.

Lime, sulphate	.....	0.6263	0.0309
Magnesia, sulphate	0.0541	.....	.....
Potash, sulphate	.0355	.....	.....
Soda, sulphate	.0600	.....	.....
Soda, carbonate	.1448	.....	.....
Calcium, chloride	.....	3.0246	.5794
Magnesium, chloride	.....	2.9881	.7837
Sodium, chloride	1.9409	34.4313	10.1040
Potassium, chloride	.....	.1883	.1120
Magnesium, bromide	.....	.0157	a trace.
Magnesium, iodide	.....	.0096	a trace.
Lithium, chloride	a trace.	.0181	a trace.
Total saline matters	2.4363	41.3188	11.8750

The water from Mr. Sutton's well smells strongly of hydro-sulphuric acid; which was not estimated, because this could only be done correctly at the well. All these waters contain, in addition, a little *organic matter*, and a little *silica* in the boiled water.

The amount of saline matters in Mr. Gains' well water is remarkable, being about five ounces and a half to the wine gallon. The saline matters in quantity and in kinds resemble those of the oceans; and doubtless had their origin in the ancient sea under which our rock strata were deposited.

Another well bored by Mr. Wm. Adams, on his farm next adjoining that of Mr. McGrath, gave water at the depth of about seventy-eight feet; which rose fifty feet in the bore. Much gas was blown out during this boring also.

The water of this well contained 0.54 of saline matter in the thousand of the water; which, tested qualitatively, was found to contain sulphuric, carbonic, and phosphoric acids, chlorine, lime, magnesia, potash, iron oxide, and a trace of lithium. It doubtless resembles that of Mr. McGrath, but is weaker. It, like that, smells strongly of petroleum.

Mr. Jno. Keiser bored to the depth of about two hundred and sixty feet, on an elevated ridge on his farm, about six miles from Lexington, on the Newtown Turnpike, and obtained only a very small quantity of brackish water, which gradually rose to within sixty feet of the surface. Some of the borings, taken at various depths, were preserved for examination. They indicate the usual layers of limestone, with thin marly shales and occasional silicious beds, of the formation in this region.

FRANKLIN COUNTY.

No. 1431—"GREEN MARLY SHALE *from below the Arsenal at Frankfort. Bed about eight inches thick (Upper Cambrian Group). Collected by Prof. N. S. Shaler.*"

A friable shale of a greyish-green color.

No. 1432—"MARLY SHALE. *Same locality as the preceding, but lying above that. Collected by N. S. Shaler.*"
Quite friable. Of dull olive and brownish colors.

No. 1433—"MARLY SHALE. *Used as a paint at Frankfort, &c. Sent by Mr. James L. Sneed for analysis.*"
Of an olive-grey color, with some brownish-yellow mixed.

No. 1434—"MARLY SHALE. *From Armstrong farm, Bridgeport. Geological position Cincinnati Group, just below the silicious mudstone. In same position as the marl near Newport. Collected by Prof. N. S. Shaler.*" *Used for paint. Said to be good for polishing iron, &c.*"
Of a handsome light olive-grey color.

COMPOSITION OF THE FIRST TWO OF THESE MARLY SHALES, DRIED AT 212° F.

	No. 1431.	No. 1432.
Alumina, and iron and manganese oxides	10.415	15.395
Lime, carbonate	1.440	*.875
Magnesia	.800	2.298
Phosphoric acid	.435	.460
Sulphuric acid	.738	.570
Potash	3.488	3.565
Soda	.042	.318
Water expelled at red heat	5.350	6.400
Silex and insoluble silicates	77.380	70.060
Total	100.088	99.941
Per centage of potash in the silicates	4.991	3.565
Per centage of soda in the silicates	.654	.430

*Lime.

These marly shales are remarkable for their large per centage of potash; which probably may make them valuable for application to exhausted land of a light and sandy nature. A previous moderate calcination with lime intimately mixed, might, if practicable, make them more available in this respect by setting free more or less of the potash locked up in the insoluble silicates. It will be seen that No. 1431 contains in

all, as much as 8.479 per cent. of potash, and No. 1432 a total amount of 7.130 per cent.

These, and similar marly shales, have been used as pigments; for which purpose they are quite appropriate, if of an agreeable tint, as they will not decompose the oil with which they are mixed, are not readily altered by atmospheric agencies under such conditions, and contain nothing of a poisonous nature. Their use for scouring or polishing depends on the very fine silicious sand contained in them.

COMPOSITION OF THE LATTER TWO OF THESE FRANKLIN COUNTY MARLY SHALES, DRIED AT 212° F.

	No. 1433.	No. 1434.
Silica	50.360	52.060
Alumina	16.816	18.831
Iron and manganese oxides	6.997	9.200
Lime	8.736	3.666
Magnesia	.936	1.210
Phosphoric acid	.217	.319
Sulphuric acid	2.280	.920
Potash (total)	3.623	5.402
Soda (total)	1.731	.720
Carbonic acid Water and loss	8.304	7.672
Total	100.000	100.000
Per centage of phosphorus	.095	0.139
Per centage of sulphur	.912	.368

Although the sulphur and iron in these marls are calculated in these analyses as sulphuric acid and iron oxide, severally, a portion of each, not determined, is combined as iron sulphide. These two analyses are tabulated separately from the first two of similar marls of this county, because in these latter analyses the method of *complete* decomposition by fusion was employed, while the first two were analyzed by digestion of the marls in acids, and the subsequent fusion of the insoluble silicious residue for the determination of the total amount of the alkalies. The remarks appended to the first two apply equally to these.

No. 1435—"WATER *from a bored or driven well, near the Kentucky river. Water stands about thirty-four feet from the surface of the ground, which is twelve to fourteen feet above low water level in that river. The height of the well water is affected by that of the river. Used in the steam boiler of the Frankfort Cotton Mill Company.*"

The sample of the water, together with some of the white powdery sediment and hard scale of the boiler, were sent to the laboratory by Mr. Milton McGrew, President of the company.

Nothing had been added to the water in the boiler, and the sediment and scale had been taken out of the boiler after running with this water for two weeks.

COMPOSITION OF THE WELL WATER IN 1000 PARTS.

Held in solution in the water by the free carbonic acid deposited on boiling.

Free carbonic acid	not est.
Lime carbonate	0.2493
Magnesia, carbonate	.0032
Silica	.0005
Sediment on boiling	0.2530

Contained in the boiled water.

Lime sulphate	0.1100
Calcium chloride	.0254
Magnesium chloride	.0174
Sodium chloride	.0460
Potassium chloride	.0142
Soda carbonate	.0413
Nitric and phosphoric acids	a trace.
Silica	.0006
	0.2549

Total saline contents of the water, 0.5079 to the thousand parts. The fresh water gives a slight alkaline reaction with reddened litmus; the soda, stated as carbonate above, is doubtless present in it as bi-carbonate.

On examination of the *white powdery boiler sediment*, it was found to be mainly lime carbonate, with about five per cent. of magnesia carbonate, two to three of lime sulphate, more than one per cent. of alumina and iron oxide, with a trace of phosphoric acid, a little silica, and traces of the alkalies.

The hard *boiler scale*, on the contrary, was found to be mainly lime sulphate, with small proportions of lime and magnesia carbonates, and traces of silica, phosphoric acid, &c.

It is evident that the hard scale, which is the most injurious to the boiler, may be prevented by the addition to the water of enough carbonate of soda, say in the form of cheap soda ash, to decompose the lime sulphate. This would probably cause the sediment to be wholly powder.

No. 1436—Sulphur Mineral Water *from a bored well, ninety-six feet deep, at Fleetwood Farm of Col. J. W. Hunt Reynolds, near Frankfort.*

The water stands at about twenty-five feet from the bottom.

COMPOSITION OF THIS WATER.

	In 1000 parts.	In a wine gallon (231 cubic inches).
Free hydrosulphuric acid gas	0.0343 parts.	1.9981 grains.
Free carbonic acid gas	.2772 "	16.1730 "
Held in solution by the free carbonic acid.		
Lime carbonate	.1397 parts.	8.1350 grains.
Magnesia carbonate	.1029 "	6.0030 "
Iron and manganese carbonates	marked traces.	marked traces.
Total sediment on boiling	0.2426	14.1380
Potash sulphate	.2535 parts.	14.7800 grains.
Sodium sulphide	.1057 "	6.1670 "
Sodium chloride	1.0152 "	59.2140 "
Potassium chloride	.0798 "	4.6580 "
Calcium chloride	.0713 "	4.1620 "
Magnesium chloride	.0228 "	1.3330 "
Silica	.0343 "	2.0000 "
Organic matters	a trace.	a trace.
Bromine, iodine, and lithium	marked traces.	marked traces.
Total	1.8250 parts.	106.4420 grains.

A very good saline sulphur water, which may be useful in cutaneous and parasitic diseases, granular sore eyes, some forms of neuralgia and rheumatism, &c., &c., when employed

externally or internally under the advice and direction of a physician.

This water was analyzed by the writer, for Col. Reynolds, before the reörganization of the Geological Survey; but it has been reëxamined recently in this laboratory, and, in addition to the ingredients reported to him, notable quantities, not quantitatively estimated, of iodine and lithium, were observed in it. The water acquires a yellowish tint on standing in bottles; doubtless owing to the formation of sulphuretted sulphide of sodium by the decomposing influence of the atmospheric oxygen on the hydrosulphuric acid.

FULTON COUNTY.

No. 1437—SOIL. *Labeled "Sub-soil of an old tobacco field. The soil proper has been washed away. Field about one hundred and fifty feet above the Mississippi river, four miles east of Hickman. Collected by Prof. N. S. Shaler."*

This sub-soil is of a brownish dark-buff, or light yellowish-brown color.

COMPOSITION, DRIED AT 212° F.

Organic and volatile matters	2.250
Alumina, and iron and manganese oxides	6.005
Lime carbonate	.230
Magnesia	.414
Phosphoric acid	.172
Sulphuric acid	not est.
Potash	.159
Soda	.072
Sand and insoluble silicates	90.490
Water expelled at 380° F.	.650
Total	100.442
Hygroscopic moisture, per cent.	2.250
Potash in the insoluble silicates, per cent.	1.479
Soda in the insoluble silicates, per cent.	1.306

It will be seen that in this sub-soil, which contains a very large proportion of fine sand and insoluble silicates, and which

only gave up 0.159 per cent. of its potash after long digestion, with heat, in chlorohydric acid, there is yet a reserve supply of that alkali of more than nine times that quantity, locked up in the insoluble silicates. This potash, although not immediately available for the use of plants, will doubtless be gradually brought into an available condition, under the slow but certain action of the atmospheric agencies and under that of *humus*, &c.

No. 1438—MINERAL WATER. "*Chalybeate water, sent by Mr. B. R. Walker, from Nick Combs' Spring, four miles southwest of Hickman, Fulton county.*"

This chalybeate water contains free carbonic acid and 0.302 of *saline matters* in the one thousand of water. This consists of iron, manganese, lime and magnesia carbonates, with some lime and magnesia sulphates, &c. The quantity sent was too small for a thorough analysis.

It is probably a valuable chalybeate water.

No. 1439—"INDURATED SILICIOUS CLAY. *From the bluffs, one hundred feet above low water mark, Hickman, Fulton county. Tertiary formation. Collected by Prof. N. S. Shaler.*"

Of a light-grey color, with ferruginous infiltrations. Breaks readily, with an irregular fracture. Adheres slightly to the tongue. Is somewhat plastic when powdered and rubbed up with water. When calcined, is of a light buff color.

No. 1440—"SILICIOUS CONCRETION *or soft sandstone from the Bluff at Hickman, fifty feet above low water. Tertiary. Collected by Prof. N. S. Shaler.*"

A whitish, porous, and friable silicious rock or concretion; adheres to the tongue. Only slightly plastic when powdered and rubbed up with water. Burns of a light buff color.

No. 1441—"SILICIOUS CONCRETION *or soft sandstone, from Chickasaw Bluff, eight miles south of Hickman. Tertiary. Bed ten feet thick. Collected by Prof. N. S. Shaler.*"

A light-grey or dove-colored soft and porous silicious rock, adhering to the tongue. Scarcely at all plastic when powdered and rubbed up with water.

No. 1442—"SOFT SANDSTONE. *Chickasaw Bluff, near the base, eight miles south of Hickman.*"

A dull light-yellowish-grey porous soft sandstone; adheres strongly to the tongue. Composed of minute rounded quartzose grains, with a whitish cement.

COMPOSITION OF THESE FULTON COUNTY SOFT SANDSTONES AND SILICIOUS DEPOSITS, DRIED AT 212° F.

	No. 1439.	No. 1440.	No. 1441.	No. 1442.
Silica	74.960	81.060	89.160	94.060
Alumina, and iron and manganese oxides	18.350	13.609	7.809	3.129
Lime carbonate	.560	.560	.380	.380
Magnesia	.309	.139	.086	.173
Phosphoric acid	.051	.051	.051	.051
Sulphuric acid	.501	.844	.707	.981
Potash	.230	.231	.115	.230
Soda	.124	.021	.080	.124
Water expelled at red heat	5.800	3.600	2.400	1.600
Total	100.885	100.115	100.788	100.728

These silicious deposits do not contain enough mineral fertilizing ingredients to make them valuable for application to the soil, nor enough alumina to constitute good plastic clay. Yet they may be made useful in tempering clay which contains too much alumina, or for the formation of common glass and for scouring purposes. Some of them are plastic enough to enable them to be moulded, and the silicious material is fine enough, in some, to permit them to be used as "Bath Brick" for household scouring. Common brick could probably be made out of No. 1439.

Some of these layers, in which the proportions of alkalies, lime, magnesia, and iron oxide are small, may perhaps be manufactured into a kind of fire-brick.

Part of the sulphur which appears in the above summary of analyses as sulphuric acid, is doubtless in combination with some of the iron in the sandstone, in the form of iron sulphide:

the oxidation of which may account for a portion of the excess in the total.

No. 1443—"CLAY *from the foot of Grand Chain, Illinois. Post Tertiary. Collected by Prof. N. S. Shaler.*"

Of a light-grey-dove color, with brownish incrustations. Fracture large conchoidal-hackly; quite porous; adheres strongly to the tongue; grinds easily into a tough plastic mass with water. Calcines of an orange-buff color; but fuses before the blow-pipe. *Specific gravity*, in its porous state = 1.764. Contains minute glimmering scales of mica.

COMPOSITION, DRIED AT 212° F.

Silica	70.660	
Alumina, and iron and manganese oxides	20.309	
Lime carbonate	.960	
Magnesia	.307	
Sulphuric acid	1.188	= .475 per cent. of sulphur
Phosphoric acid	.051	
Potash	.819	
Soda	.487	
Water expelled at red heat, and loss	5.219	
	100.000	

This clay, which was collected for comparison with the Fulton county tertiary deposits, would prove of no especial value as a fertilizer, except on very sandy soils to improve their consistence. It would probably answer for common pottery or bricks; but is too fusible for fire-brick. It compares pretty well with No. 1439.

GRAYSON COUNTY.

No. 1444—CLAY IRON-STONE "*From three miles south of Litchfield. A six inch layer, on the land of Jno. H. Higden, in the carboniferous limestone. On the old Brownsville road. Collected by Prof. N. S. Shaler.*"

Fine granular, or compact. Dark grey.

COMPOSITION DRIED AT 212° F.

Iron, carbonate	60.466	= 33.630 per cent. of iron.
Iron, peroxide	6.536	
Alumina	7.179	
Lime carbonate	4.050	
Magnesia, carbonate	6.378	
Manganese, carbonate	a trace.	
Phosphoric acid	.102	= 0.035 per cent. of phosphorus.
Sulphuric acid	.054	= .022 per cent. of sulphur.
Silica and insoluble silicates	14.450	= 11.900 per cent. of silica.
Water and loss	.785	
	100.000	

Quite a good ore of its kind.

No. 1445—LIMONITE IRON ORE. *"From north side of Grindstone branch of Rock Creek. Hill below Owen Whittrie's. Grayson county. Collected by P. N. Moore."*

A porous and cellular limonite, varying in color from dark brown and steel black to reddish-brown and ochreous.

COMPOSITION, DRIED AT 212° F.

Iron, peroxide	27.192	= 19.344 per cent. of iron.
Alumina	4.299	
Manganese, brown oxide	a trace.	
Lime carbonate	.410	
Magnesia	.317	
Phosphoric acid	.249	= 0.109 per cent. of phosphorus.
Sulphuric acid	.103	= .041 per cent. of sulphur.
Water expelled at red heat	5.600	
Silica and insoluble silicates	61.730	= 25.500 per cent. of silica.
Moisture and loss	.100	
	100.000	

This ore is too poor in iron and too silicious to be of much value.

[See Appendix for other Grayson county iron ores.]

No. 1446—MARLY SHALE. *"From Sunset Lick, a mile and a half west of Litchfield. Geological position the carboniferous formation. Collected by Prof. N. S. Shaler."*

A friable marly shale of a greyish and brownish-olive color. This marl, when analyzed by digestion in acids, &c., gave the following results, dried at 212° F., viz:

Alumina, and iron and manganese oxides	19.133
Lime	.269
Magnesia	.353
Phosphoric acid	.267
Sulphuric acid	.027
Potash	2.910
Soda	.052
Water expelled at red heat	6.230
Silica and insoluble silicates	71.580
Total	100.821

The *silica and insoluble silicates*, when *sintered* with lime carbonate and ammonium chloride, &c., &c., yielded 1.205 per cent of *potash*, and 0.55 per cent. of *soda*, in addition to that given above as extracted by digestion in acids. So that the *total* amount of potash in the marl appears to be 4.115 per cent. and that of soda 0.602 per cent.

Some of the same marly shale, from this locality, subsequently collected by Mr. P. N. Moore, was analyzed by fusion with the mixed alkaline carbonates; *sintering* with lime carbonate and ammonium chloride, &c., &c., and gave the following results, viz:

Alumina	14.130
Iron and manganese oxides	13.480
Lime	.538
Magnesia	1.158
Phosphoric acid	.280
Sulphuric acid	.204
Potash	4.625
Soda	.783
Water, &c., expelled at red heat	6.000
Silica	60.060
Total	101.258

The apparent excess in the total may be partly due to oxidation of combined iron and sulphur in the marl, and probably, also, to an over-estimation of the water.

Its considerable proportion of *potash* might make it useful as a fertilizer on impoverished land, were this alkali all in *an available* condition. But the analyses show that a great portion of it is in firm combination, in the silicates insoluble in acids; only to be released, and made available for plant growth, by the slow process of weathering, under the influence of atmospheric agencies, *humus*, &c. Whether lime could be profitably employed to decompose these silicates and set free the alkalies, is yet to be tried.

The remarks given under the head of marly shales of Campbell and Franklin counties, as to their use as "mineral paint," &c., apply to this marly shale also.

No. 1447—"SOFT SANDSTONE; *a micaceous, uncemented sand rock, from Horse Branch, on the Elizabethtown and Paducah Railroad. Border of Grayson and Ohio counties. Very friable. Can be shoveled like sand. Collected by Prof. N. S. Shaler. Geological position carboniferous.*"

Of a light drab, or grey-buff color, consisting of small quartz grains, mostly rounded, some spangles of mica, some few grains of blackish and greenish ferruginous mineral, and a fine powder, somewhat ferruginous, which can easily be washed out from the quartz sand, &c., by water. Water disintegrates the lumps.

This soft sand rock, *dried at* 212°, gave the following results, on analysis by acid digestion, &c.:

Sand and insoluble silicates	87.700
Alumina, colored with iron oxide	7.040
Lime (estimated as carbonate)	.100
Magnesia	.245
Phosphoric acid	.370
Sulphuric acid	.049
Potash	.975
Soda	.401
Water, &c., expelled at red heat	3.000
Loss	.120
Total	100.000

This would undoubtedly answer well for the manufacture of common glass. Its considerable proportion of potash, nearly one per cent. extracted by acids, has probably been mainly derived from the mica which it contains, while the phosphoric acid, also considerable for a sand, has doubtless been mostly extracted from the dark greenish mineral. This sand would prove a useful addition to heavy clay soil. No doubt analysis by fusion would show that it contains a much larger proportion of potash than digestion in acids demonstrates.

No. 1448—COAL. *Labeled "Tar Lick Coal, Dismal Creek, Grayson county. Average sample, by P. N. Moore."*

Mostly in thin laminæ, with some bituminous matter, fibrous coal, and fine-granular pyrites between them. Generally of a deep-black color, with occasional ferruginous stains.

No. 1449—COAL. *"Gravelly Lick, Miller's Fork of Bear Creek. Average sample, by P. N. Moore."*

Splitting into thin laminæ, with a little fibrous coal and fine-granular pyrites between.

No. 1450—COAL. *"Near the School-house, on Brushy branch of Calloway Creek, W. B. McGrew's. Collected by P. N. Moore."*

Much weathered.

No. 1451—COAL (*impure*) *"Copperas bank, branch of Hunting Fork of Rock Creek, above the conglomerate. Collected by P. N. Moore."*

Mostly in thin laminæ, some of which are shaly. Some ferruginous incrustation.

No. 1452—COAL. *"L. Higdon's, Pearson's branch of Rock Creek. Below the conglomerate. About fifteen feet above the limestone. Collected by P. N. Moore."*

A jet-black coal; generally breaking into thin laminæ, some of which are somewhat shaly. Not much fibrous coal or granular pyrites apparent. Some ferruginous incrustation.

No. 1453—COAL (*impure*) *"From Gum Spring Fork of Cane Camp Creek, Nolin Furnace property. Sample from above the slate parting only. Collected by P. N. Moore."*

A much weathered coal, in thin laminæ, much tarnished with ferruginous and aluminous incrustations.

No. 1454—COAL (*impure*) *"From same locality as preceding. Sample from below the slate parting only. Collected by P. N. Moore."*

In thin laminæ, some shaly; weathered dull and stained with ferruginous and clayey incrustation.

COMPOSITION OF THESE GRAYSON COUNTY COALS, AIR-DRIED.

	No. 1448.	No. 1449.	No. 1450.	No. 1451.	No. 1452.	No. 1453.	No. 1454.
Specific gravity	1.305	1.395	1.346	1.378	1.364	1.446	1.512
Hygroscopic moisture . .	4.70	4.14	6.26	3.50	3.60	6.50	4.40
Vol. combustible matters .	31.40	30.52	32.44	33.40	35.80	29.10	25.86
Coke	63.90	65.34	61.30	63.10	60.60	64.40	69.74
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters . .	36.10	34.66	38.70	36.90	39.40	35.60	30.26
Carbon in the coke . . .	52.20	50.08	53.80	47.50	49.40	49.60	40.14
Ashes	11.70	15.26	7.50	15.60	11.20	14.80	29.60
Total	100.00	100.00	100.00	100 00	100.00	100.00	100.00
Character of the coke . .	Spongy.	Dense spongy.	Light friable.	Light spongy.	Light spongy.	Friable.	Friable.
Color of the ash	Light brownish grey.	Brownish grey.	Greyish-salmon.	Lilac-grey.	Light chocolate	Light brownish	Nearly white.
Per centage of sulphur. .	1.945	3.565	1.476	2.041	3.158	0.818	0.777

No. 1455—"COAL, *remarkable for being found in the sub-carboniferous limestone; about seventy-five to a hundred and twenty feet below the Chester Group. Collected by C. J. Norwood.*"

A much weathered specimen; splitting easily into thin laminæ, with very little fibrous coal or pyrites between. Some little ferruginous stain.

COMPOSITION—SPECIFIC GRAVITY = 1.338.

Hygroscopic moisture	4.24
Volatile combustible matters	30.82
Coke (light friable)	64.94
Total	100.000
Total volatile matters	35.06
Carbon in the coke	55.52
Ashes (brownish salmon-grey)	9.42
Total	100.00
Per centage of sulphur	2.892

Interesting only because of its unusual position.

GRAYSON SPRINGS MINERAL WATERS.

These waters were mostly collected and tested qualitatively, at the springs, by Mr. Jno. H. Talbutt; who spent several days in this work and in the evaporation of a quantity of some of the principal ones, for the purpose of determining the more rare ingredients. The quantitative analyses were performed at our chemical laboratory in Lexington.

No. 1456—"SULPHUR WATER *from the Centre Spring, a natural spring, the most popular of the Grayson Springs.*"

Inclosed in a "gum" three feet deep and one and a half feet in diameter. Flows in a perennial stream, of about half an inch diameter. Gas bubbles up frequently, in moderate intermittent bursts. The water is of nearly a constant temperature of 61° F.; clear, depositing in its channel a dark-grey slimy sediment; and on the gum an incrustation varying in color from blackish and brownish to greenish and pinkish.

The spring is about two hundred yards southeast from the hotel. Has a reputation as diuretic, aperient, &c., &c. Reaction of the recent water is neutral with litmus paper, but when it has been partly evaporated it is slightly alkaline.

No. 1457—SULPHUR WATER *from the Moreman Spring.*

A natural spring, inclosed in a sycamore "gum" (twenty-two inches deep by eleven in diameter). Stream constant the

year round, through a three-quarter inch hole. Bubbles of gas rise intermittently. Sediment in the channel of overflow, whitish; that at the bottom of the gum greenish-black, and slimy. Temperature of the water 66° to 67° F., nearly constant.

Considered one of the best of the waters for cutaneous diseases. Acts pretty constantly as aperient. Reaction of the recent water, neutral.

No. 1458—SULPHUR WATER *of the McAtee* Sulphur Spring.*

A natural spring (said to have two sources, one warm the other cold), located at the base of the hill, farthest of all from the house, nearest to the creek; near the bath-house. Included in a wooden box, fourteen by twenty-two inches, and twenty inches deep. The flow is about sufficient to fill a half inch pipe. There is a slight intermittent evolution of gas. Temperature, said to be invariable, at 60° F. The sediment in the box is dark green, with much pinkish; slimy. The incrustation on the box, greenish of various tints and shades. This water is not quite so strong as that of the "Center Spring."

No. 1459—SULPHUR WATER *of the "Stump Spring."*

A natural spring, included in a sycamore "gum," twelve inches in diameter and twenty deep. The flow is about a quarter to half inch in diameter. There is a slight evolution of gas in bubbles. Temperature of the water 64° F., said to be invariable. The sediment in the gum is blackish and slimy. The incrustation very slight, and nearly black. The taste of the water is sweetish-brackish. Reaction with litmus papers, *neutral.*

No. 1460—SULPHUR WATER *of the "Jar Spring."*

A natural spring, nearest to the house (near the Stump and Big Gum Springs), included in a gum twelve inches in diameter

*Called by Dr. Owen "Macatine." Volume 1, Kentucky Geological Reports, page 270.

and twenty-six deep. Flow of water from quarter to half an inch in diameter. Slight evolution of gas in bubbles, smelling strongly of sulphuretted hydrogen, as do all the others. Temperature of the water 63° F., said to be constant. Taste sweetish. Reaction, *neutral.* The sediment is dark-colored; slimy. The incrustation on the gum whitish, with greenish and purplish tints.

No. 1461—SULPHUR WATER *from the "Eye Spring."*

A natural spring, included in a "gum" ten to eleven inches in diameter and twenty deep. The flow of water is about a quarter of an inch in diameter. Temperature of the water, 66° F., said to be invariable. (The temperature of the atmosphere, at the time of observation, was 86° F.) Very little evolution of gas bubbles. The sediment in the gum is dark, and slimy. The incrustation on the gum dark green, yellowish, and purplish, and dirty-whitish. Taste brackish. Reaction, *neutral.*

No. 1462—SULPHUR WATER *from the "White Sulphur Spring," near the "Big Gum," and between it and the Moreman Spring, to the left of the walk.*

Flow about quarter to half an inch in diameter. A slight intermittent evolution of gas bubbles. Temperature 62° F., said to be invariable. Incrustation whitish. Sediment greenish near the gum. Tastes and smells stronger of sulphuretted hydrogen than any of the other springs. Reaction, *neutral.* Water not at present used.

No. 1463—SULPHUR WATER *from the "Hymenial Spring."*

A feeble spring, situated about ten feet from the "Center Spring." Temperature of the water 65° F., said to be invariable. Sediment greenish-black, with pinkish portions, and slimy. Incrustation on the "gum" dark-green and dirty-white. Reaction, *neutral.*

No. 1464—SULPHUR WATER *from the "Rock Spring."*

The original spring of the group. Situated at the base of the hill. Flows out from the rock in a constant stream, which might fill an inch pipe. Temperature 58° F., said to be invariable. A whitish scum on the water in the channel of out-flow; no gas bubbles evolved. Sediment bluish-blackish. Reaction, *neutral.* Not very strong in sulphuretted hydrogen.

No. 1465 — SULPHUR WATER *from an Artesian Well, one thousand feet deep, and six inches in diameter, completed in* 1865.

Bored for "oil" on Hunting Fork, a tributary of Rock Creek, near Mr. H. Haynes', six miles from Grayson Springs, on the property of the Boston Kentucky Central Rock Oil Company, H. W. Fuller, President. At first the water spouted twenty feet above the surface of the ground, from the two-inch tube. The tube is now out, and the hole has been widened for six feet down and cased with an eight-inch square wooden box. The water now flows out in a six-inch stream. Temperature 61.5° F. Gas is evolved constantly in large bubbles. The incrustation on the boxing, &c., is blackish, and is to be seen in the channel of the stream for half a mile down. The water is clear and colorless, and gives an *alkaline reaction.* A salt water stream is said to enter the well about one hundred and fifty feet below the surface.

COMPOSITION OF THESE SULPHUR WATERS OF GRAYSON COUNTY IN 1000 PARTS.

Name of spring	Centre.	More-man.	McAtee.	Stump.	Jar.	Eye.	White Sulphur.	Hyme-nial.	Rock.	Artesian
	No. 1456	No. 1457	No. 1458	No. 1459	No. 1460	No. 1461	No. 1462	No. 1463	No. 1464	No. 1465
Specific gravity of water	1.0022	1.0011	1.0015	1.0016	not est.	not est.	not est.	not est.	not est.	not est.
Free carbonic acid gas .	0.1950	0.1234	0.1500	0.1650	0.2020	not est.	not est.	not est.	not est.	not est.
Free sulphuretted hydrogen gas	.0200	.0248	.0203	.0410	.0265	0.0239	0.0270	not est.	not est.	0.0380
Lime carbonate . . .	0.1736	0.1952	0.1806	0.2002	0.1632	0.1872	0.1832	0.1525	0.1660	0.1360
Magnesia carbonate . .	a trace.	.0512	.0002	a trace.	.0345	.0042	.0018	not est.	.0118	.0228
Iron, and manganese carbonates and phosphates	.0027	.0048	.0078	.0066	.0072	.0096	.0096	. . . .	.0072	.0106
Silica	.0022	.0094	.0028	.0008	.0032	.0026	.0104	. . . .	.0022	.0260
Organic matters and loss	not est.	not est.	.0022	.0268	.0271	.0096	.0090	. . . .	.0304	.0038
Total sedi'nt on boiling	0.1785	0.2606	0.1914	0.0342	0.2352	0.2132	0.2140	not est	0.2176	0.1992
Lime sulphate	1.1649	0.4541	0.4528	0.6291	0.5078	0.6683	0.6505	0.9001	0.5946	1.3044
Magnesia sulphate . . .	.5774	.3768	.4616	.6093	.5781	.7542	.6522	.8835	.4704	.8778
Potash sulphate	. . . .	. . . .	.0024	.0023	.0045	.0017	. . . .	.0085	.0011	not est.
Soda sulphate	. . . .	. . . .	.0126	.0374	. . . .	.0147	. . . .	. . . .	.0288	not est.
Iron, manganese and alumina sulphates and phosphates	.0034	.0007	.0192	not est.	traces.	traces.	traces.	traces.	traces.	traces.
Sodium sulphide	.0521	.0409	not est.	not est.	.0207	.0100	.0257	.0220	.0059	.0254
Soda combined with organic acids	.0044	.0066	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Potash " "	.0009	.0038	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Sodium chloride . .	. . . .	. . .	.0200	.0053	.0760	.1059	.0192	.0226	.0084	.2960
Magnesium chloride . .	0.1898	.0145	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Silica	.0034	.0029	.0060	.0022	.0008	.0058	.0028	.0032	.0048	.0056
Organic matters and loss	not est.	not est.	not est.	.0200	.2029	.0222	.1777	not est.	.1484	not est.
Total saline matters .	2.0748	1.1609	1.3252	1.5740	1.6260	1.7960	1.7470	1.9974	1.4800	2.7084
Lithium, iodine and bromine	traces.	traces.	traces.	traces.	not est.	not est.	not est.	not est	not est.	not est.
Temperature of spring, F.	61°	66°, 67°	60°	64°	6.	66°	62	65°	53°	61°, 65°

The small quantities of lithium compound, indicated in the above table, were detected by means of the spectroscope, after proper treatment of the saline residuum obtained by the evaporation of from ten to twenty litres of the water. The bromine and iodine traces could only be observed by the appropriate tests after a similar evaporation.

The *organic matters* recorded in the table are composed of *apocrenic* and *crenic* acids and the singular substance called *Barégine*, from the fact that it was first observed in the sulphur water of the celebrated Barège Springs of the Pyrenees.

This *Barégine* is found in solution in many of the sulphur waters of the world; more especially in the thermal waters.

On evaporation of such waters they assume a yellowish tint and leave a yellowish-brown residue, which, on calcination, gives out ammoniacal fumes and the odor of burnt horn; leaving a very large proportion of ash, mainly silicious. This organic matter, approaching to the nature of the albuminoid or gelatinous principles, is what is called Barègine.

By exposure of these waters to the air this dissolved nitrogenous matter undergoes a change; becomes less soluble and forms a sediment, or deposit, in the spring and its channel, of a slimy nature, which is called *glairine*, and which is usually combined with other precipitated materials from the water, such as iron and manganese sulphides, lime and magnesia carbonates, free sulphur, &c., &c., and probably changes, by gradual decomposition, into *crenic* and *apocrenic acids*, &c.

Glairine, with crenic and apocrenic acids, and other substances mentioned above, were abundantly found in the unctuous slimy sediment of these Grayson sulphur springs. Generally more of the latter than of the crenic.

This sediment was collected by Mr. Talbutt from the bottom of the water in the "gum" usually, from the following springs, viz: "Centre," "Moreman," "McAtee," "Stump," and "Hymenial," and brought to the laboratory for examination, in close bottles, with some of the water of the spring included.

On examination, some weeks afterward, the supernatant water was found to be glairy in all except that from the *Stump* Spring. In those from the Centre and Moreman springs the water over the sediment was of a dirty-olive green color, of a sulphurous and putrescent odor, *glairy*, and as thick as ordinary white of egg. When this was poured off and the sediment agitated with more distilled water, this also became glairy and colored, on standing; and the same result was obtained in a second and third operation of the kind; the quantity of the dissolved organic matter appearing gradually to be diminished. The "Centre" sediment gave the most of this glairy material; that of the "Moreman," "McAtee," and "Hymenial" gave less, and that of the "Stump," although it colored the water slightly, did not make it glairy or communi-

cate to it the semi-putrescent, sulphurous odor, so marked with the others.

The glairy colored solution, poured off from the sediment, was evaporated and analyzed. The dark brownish solid residuum, obtained by evaporation, presented the usual properties of *glairine*. It burnt with a burnt-horn, ammoniacal odor, leaving a large quantity, more than forty per cent., of whitish *ash*. This ash was largely *silicious*, but contained also *alumina*, *iron* and *manganese oxides*, *lime*, *magnesia*, and *phosphoric* and *sulphuric acids*. The glairley soluble matter also contained apocrenic acid.

The dark colored original sediments, which had thus been washed with water to remove some of the glairine, &c., were found to contain much *apocrenic* and *crenic* acids, especially the former, with alumina, iron and manganese oxides, lime, magnesia, phosphoric and sulphuric acids, sulphur, &c. Becoming somewhat charred when calcined and giving off the odor of burnt animal and vegetable matters. That from the "Centre" Spring giving more of the odor of burnt animal matter. Those of the others giving mostly the odor of burnt vegetable matter.

Doubtless the other sulphur waters of this locality also contain these remarkable organic ingredients, or most of them. What influence they have in therapeutic applications of these waters has not been determined. It is probable, however, that this decomposable organic material, from whatever unknown source derived, may, by reaction upon the dissolved earthy sulphates of the water, produce some of the sulphydric acid which it contains.

It may be interesting to append the chemical composition of *glairine* of three different varieties, as determined by J. Bouis. (*"Comptes Rendus," XLI, page* 116.)

	Carbon.	Hydrogen.	Nitrogen.	Ashes.
Glairine, pulpy, grey	48.69	7.70	8.10	30.22
Glairine, fibrous, red	44.06	6.69	5.57	35.00
Glairine, pulpy, green	45.20	6.95	5.60	40.07

No. 1466—CHALYBEATE WATER, *from the chalybeate well at Grayson Springs.*

Well ten feet deep; walled up with rock, three feet square. Water about four feet deep in well. It is said that three streams of chalybeate and one of fresh water flow into it. A very slight occasional evolution of gas. Temperature of the water, 71° F. The water is raised with a wooden pump. The sediment or deposit, where the water flows from the pump and trough, is ferruginous, brownish-red. Reaction, *neutral.*

No. 1467—CHALYBEATE WATER, *from a well near Grayson Springs; sent by Mr. Van Meter, proprietor of the springs, for examination.*

This, like the preceding, deposited a flocculent light-brown ferruginous sediment in the containing bottle.

No. 1468—CHALYBEATE WATER, *from "Indian Spring," a natural source, near Jones' Mill; head of Sunfish Creek, five miles from Paducah and Louisville Railroad. Sent for examination by Mr. H. Haynes.*

This also deposited a brownish ferruginous sediment in the bottle.

COMPOSITION OF THESE CHALYBEATE WATERS, IN 1000 PARTS OF THE WATER.

	No. 1466.	No. 1467.	No. 1468.
Free carbonic acid	0.207	not est.	not est.
Lime carbonate	0.1251	0.2580	0.0076
Magnesia carbonate	a trace.	.0020	a trace.
Iron and manganese carbonates and phosphates, with traces of alumina	.0118	.0800	.0133
Silica	.0022	.0180	.0028
Total, held in solution by carbonic acid	0.1391	0.3580	0.0237
Lime sulphate	0.0110	2.328	.0692
Magnesia sulphate	a trace.	.741	a trace.
Potash sulphate	a trace.	.063	a trace.
Soda sulphate	a trace.	1.130	a trace.
Sodium chloride	.0081	.1510	.0423
Potassium chloride	.0076		.0038
Silica	not est.	.0150	.0086
Total saline contents	0.1658	4.786	0.1476

From these analyses, which can only be considered approximative, it appears that the water from the well near Grayson Springs is the strongest and the most aperient. The small quantity of the water sent, and the alterations which always take place in waters of this kind, under the influence of the atmosphere, prevent these examinations from being entirely conclusive.

No. 1469—SOIL. *"Sample to the depth of eight inches from an old field, fifty years in cultivation, which has been lying uncultivated for the last fifteen years. Collected by C. Schenk."*

Situated twenty-five hundred feet west of the twenty-first mile-post on the Louisville and Paducah Railroad; west of Big Clifty. Locality, six hundred and seventy feet to the right of that road and four feet above the level of the rail. Underlying rock, *sandstone*. *Timber* of the locality, mostly black oak, with some white and red oak; with a few poplars on the creeks. *Undergrowth* sumach, dogwood; much sassafras and persimmon. *Rotation of crops*: 1. Tobacco; 2. Corn; 1. Oats; sometimes with clover. No manure. *Yield:* of corn and oats, of each ten bushels to the acre. Soil of a yellowish light-umber color.

No. 1470—SOIL. *"Sub-soil of the preceding, taken at a depth of from eight to forty inches. Collected by C. Schenk."*

Sub-soil of a dull-light-brick color.

No. 1471—"VIRGIN SOIL. *Sample to depth of six inches. Collected by C. Schenk."*

From a point two hundred feet east of the twenty-second mile-post, on above named railroad; two hundred and fifty feet to the right of the road, and four feet above the level of the rail. Underlying rock, *sandstone*. Has been two years in cultivation. Usual yield of this locality, according to report of the farmers, of corn and oats, each ten to twenty bushels, and of wheat five to ten bushels. It yields tobacco only when manured. Timber same as in preceding.

Soil of a greyish-brown or light umber color. The coarse-sieve (two hundred and eighty-nine meshes to inch) removed from it a few rounded ferruginous particles only.

No. 1472—"Sub-SOIL *of the next preceding; taken to the depth of from six to thirty-six inches. Collected by C. Schenk.*"

Sub-soil of a light greyish-buff color. Contains a few small rounded ferruginous particles.

No. 1473—"VIRGIN SOIL, *three years in cultivation. Collected by C. Schenk.*"

Sample to the depth of seven inches, from a locality one thousand feet west of the twenty-sixth mile-post, on the Louisville and Paducah Railroad, and three hundred and sixty feet to the left of that road, at the level of the rail. Drainage slope = 1:150. Substratum, *limestone.* Timber, red, black, and white oak, with sugar-tree and poplar. Timber full of holes, except the poplar. Undergrowth, dogwood, sassafras, persimmon. Sometimes one hundred cords of wood to the acre.

Rotation of crops: two years in corn; yield, twenty-five bushels to the acre; one year in oats; same yield. New land here yields fifteen to thirty bushels of corn, twenty to thirty of oats, and eight hundred to a thousand pounds of tobacco, per acre.

Soil of an umber color; darker than the preceding virgin soil. It contains a few rounded ferruginous particles.

No. 1474—"SUB-SOIL *of the next preceding, taken at the depth of from seven to thirty-six inches. Collected by C. Schenk.*"

Sub-soil of a light grey-buff color. Contains a few small rounded ferruginous particles.

No. 1475—SOIL. "*Sample to the depth of five and a half inches, of an old field, forty years in cultivation. Collected by C. Schenk.*"

Near the Grayson Spring Station, Louisville and Paducah Railroad, four hundred and fifty feet to the right of that road,

at a point five hundred and thirty feet east of the twenty-six mile-post. Fifteen feet above the level of the rail. Drainage slope = 1:30. Substratum, *limestone.* Rotation of crops: two years in corn, one in oats and clover (sometimes tobacco first). Field has been in grass for the last three years. Yield: corn, twelve to twenty bushels; wheat, eight; and oats, fifteen per acre.

Dried soil of a brownish-grey color. Sifted out very few small rounded ferruginous particles.

No. 1476—"SUB-SOIL *of the next preceding, taken from five and a half to thirty-six inches below the surface. Collected by C. Schenk.*"

Sub-soil of a grey-buff color. Contains but few rounded ferruginous particles.

NOTE.—For the rest of this serial collection of soils, &c., made by Mr. Schenk, on and near the line of the Elizabethtown and Paducah Railroad, see Hardin and Ohio counties.

COMPOSITION OF THESE GRAYSON COUNTY SOILS, &c., DRIED AT 212° F.

	No. 1469	No. 1470	No. 1471	No. 1472	No 1473	No. 1474	No. 1475	No. 1476
Organic and volatile matters	3.850	3.375	4.85	3.200	4.950	3 350	4.500	3.275
Alumina, and iron and manganese oxides	7.215	10.990	5.515	7.497	6.195	6.647	4.172	6.022
Lime carbonate	.345	.195	.145	.045	.340	.020	.220	.145
Magnesia	.240	.159	.140	.140	.176	.104	.167	.125
Phosphoric acid	.076	.166	.125	.093	.125	.093	.113	.093
Sulphuric acid	Not estimated.							
Potash	.243	.308	.112	.105	.327	.105	.120	.405
Soda	.125	.104	.051	.044	.023	.070	.045	. . . .
Sand and insoluble silicates	86.850	84.490	88.79	87.565	86.780	88.965	90.640	89.580
Water expelled at 380° F.	925	.425	1.325	.875	1.075	1.100	1.100	.350
Loss	.131	. . . .	. . . .	.436	.009	. . . .	. . . .	.005
Total	100.000	100.212	101.053	100.000	100.000	100.454	101.082	100.000
Moisture expelled at 212° F.	2.025	2.925	2.125	2.700	1.950	1.650	1.775	3.500
Potash in the insoluble silicates	1.0395	. . . .	1.002	. . . .	. . . .	. . . .	. . . .	.828
Soda in the insoluble silicates	0.479	. . . .	.377	. . . .	. . . .	. . . .	. . . .	.624
Character of the soil	Old field soil.	Sub-soil	Virgin soil.	Sub-soil	Virgin soil.	Sub-soil	Old field soil.	Sub-soil

Although these Grayson county soils cannot be classed amongst the naturally very rich soils, because they are rather too sandy; yet, if they are well drained, they may be made quite profitable with proper management and by the judicious

use of fertilizers. There is no reason, except unskillful culture, why they are not at present more productive than is represented above. Their near vicinity to good markets should introduce a more scientific husbandry.

GREENUP COUNTY.

No. 1477—CLAY. *Labeled "Fire-clay, Louder's land, near Kenton Furnace. Collected by P. N. Moore."*

A compact, fine-grained, non-plastic clay-stone of a light-grey color; hardly adhering to the tongue; breaking readily into sharp angular fragments; fracture somewhat conchoidal. This, when reduced to powder, easily works up with water into a plastic mass, which is the case with the other samples of this kind described below.

No. 1478—"FIRE-CLAY, *two feet above the limestone ore; head of Powder-mill hollow, two miles from Kenton Furnace. Collected by P. N. Moore."*

An olive-grey shaly clay, breaking easily into layers, but not so easily across them; adhering to the tongue.

No. 1479—"CLAY, *fourth above the limestone and limestone ore, on Pea Ridge. Thickness two to two and a half feet. Weathering white. Collected by J. A. Monroe."*

A whitish clay, in soft friable lumps; colored with oxide of iron in the crevices.

No. 1480—"CLAY; *thin bed, resting on limestone ore of Pea Ridge, near Hunnewell."*

A soft friable plastic clay; colored olive-green and brownish and yellowish-grey.

No. 1481—"CLAY. *Two and a half feet bed; second above limestone ore. Pea Ridge. Collected by J. A. Monroe."*

Olive-brownish-grey. Harsh to the feel. Breaks in angular fragments.

No. 1482—"CLAY, *fourteen inches thick. Third bed above the limestone ore at Pea Ridge. Collected by J. A. Monroe.*"

A brownish-grey compact clay, breaking into irregular layers, which are polished on their surfaces; adheres slightly to the tongue.

No. 1483—CLAY. "*Fire-clay. Thomas' bank. Average sample of upper layer; five feet above the cherty limestone. Head waters of Wing's branch of Shultz Creek. Collected by P. N. Moore.*"

A compact clay-stone of a light-grey color (yellowish and bluish); even fracture; soapy feel; not scratched by the nail; scarcely adhering to the tongue.

COMPOSITION OF THESE GREENUP COUNTY CLAYS, DRIED AT 212° F.

	No. 1477	No. 1478	No. 1479	No. 1480	No. 1481	No. 1482	No. 1483
Silica	49.680	62.920	66.560	47.060	67.700	55.560	47.560
Alumina	35.281	20.735	22.679	36.620	22.092	31.027	40.661
Iron oxide, &c.	a trace.	3.820	a trace.	a trace.	a trace.	a trace.	a trace.
Lime	.213	.213	.157	.615	.101	.325	.280
Magnesia	.136	2.281	.605	.389	.285	.403	.497
Phosphoric acid	.626	.371	.563	.626	.498	.358	.249
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	a trace.
Potash	.193	2.601	1.946	1.156	1.156	1.167	.308
Soda	.211	.659	.690	.234	.268	.560	.409
Water expelled at red heat, and loss	13.660	6.400	6.800	13.300	7.900	10.600	10.036
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000

On submitting these clays to the action of the blow-pipe, No. 1480 was found to be most softened by the heat, while Nos. 1477, 1481, and 1483 were most refractory; the others occupied an intermediate position. They all burnt nearly white, but No. 1478 burnt of a light-buff color, and No. 1479, No. 1480, and No. 1483 acquired a very light pink tint on being calcined. They are undoubtedly all very good clays, and the more silica they contain, within certain limits, and the smaller their proportions of potash, soda, oxide of iron, lime, magnesia, and phosphoric acid, the better they withstand the melting influence of fire.

[See Carter county for other clays of this kind.]

No. 1484—"COAL, *No.* 1, *used at Kenton Furnace. Average sample.*"

A brittle coal, breaking into irregular layers; fractured surface dark, glossy, asphaltum-like. Impressions of reedy leaves on the laminæ, and some fine-grained pyrites.

No. 1485—"COAL, *average sample, from J. Thompson's bank, near Kenton Furnace. Bed sixteen inches thick. Collected by J. A. Monroe.*"

A brittle coal, breaking into thin irregular layers, which have much pulverulent mineral charcoal between them.

No. 1486—COAL, *No.* 3. "*Average sample of the main coal of Raccoon Furnace. Below the shale parting.*"

A dark colored coal, breaking easily into thin layers. Separated by much fibrous coal, with some fine-grained pyrites diffused in it.

No. 1487—COAL, *No.* 3. "*Average sample of the upper part of the coal used at Raccoon Furnace. Mine one and a third miles east of southeast of the furnace. The upper twenty inches of the thirty-six inch bed. Collected by P. N. Moore.*"

Much like the preceding.

No. 1488—COAL. "*Main coal, No.* 3; *lower part below the shale parting. Buffalo Furnace. Averaged by P. N. Moore.*"

No. 1489—"MAIN COAL, *No.* 3; *above the shale parting. Buffalo Furnace. Averaged by P. N. Moore.*"

No. 1490—COAL. "*Alcorn Creek coal; probably sub-conglomerate. Raccoon Furnace. Averaged by P. N. Moore.*"

No. 1491—COAL, *No.* 1. "*Hanna bank coal. Average of the upper portion of the bed, from the stock pile, by P. N. Moore.*"

No. 1492—"*Hanna bank coal, &c. Averaged from the lower part of the bed, from the stock pile, by P. N. Moore. Coals identified by Mr. Witherow.*"

No. 1493—"COAL, *probably No. 3; thirty feet below the Kidney ore, Laurel Furnace. Average from coal shed, by P. N. Moore.*"

No. 1494—COAL, *No. 6; from the hill back of Amanda Furnace. Average sample from all parts of the bed, by A. R. Crandall.*"

A bright, jet-black, splint coal, with but little fibrous coal between the layers. Some slight ferruginous external stain.

No. 1495—COAL, *No. 6; from branch above the shops, Hunnewell Furnace. Averaged from the upper part of the bed only, by A. R. Crandall.*"

Splint coal. Has but little fibrous coal between the laminæ. Slight external ferruginous stain.

No. 1496—COAL, *No. 3. "From drift near Pennsylvania Furnace. Averaged by P. N. Moore.*"

A glossy jet-black coal, with fibrous coal and very little appearance of pyrites between the thin laminæ.

No. 1497—COAL, *No. 6. "From a new opening one mile above the shops at Hunnewell Furnace. (Old Greenup Furnace.) Average sample.*"

A glossy pitch-black splint coal; shows but little fibrous coal or pyrites.

[See Appendix for other Greenup county coals.]

COMPOSITION OF THESE GREENUP COUNTY COALS, AIR DRIED.

	No. 1484	No. 1485	No. 1486	No. 1487	No. 1488	No. 1489	No. 1490	No. 1491	No. 1492	No. 1493	No. 1494	No. 1495	No. 1496	No. 1497
Specific gravity	1.316	1.345	1.250	1.420	1.374	1.389	1.374	1.389	1.292	1.289	1.335	1.365	1.300	1.355
Hygroscopic moisture	4.82	4.96	4.80	4.28	3.20	2.90	3.30	4.00	3.20	4.10	4.04	4.30	3.20	3.80
Volatile combustible matters	32.90	32.98	34.64	36.52	36.26	33.76	31.90	31.66	23.90	34.96	33.62	35.60	36.60	37.70
Coke	62.28	62.06	60.56	59 20	60.54	63.34	64.80	64.34	62.90	60.94	62.34	60.10	60.20	58.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	37.72	37.94	39.44	40.80	39.46	36.66	35.20	35.66	37.10	39.06	37.66	39.90	39.80	41.50
Carbon in the coke	55.18	55.46	52.58	47.00	47.54	51.34	52.20	53.44	56.70	55.54	53.34	50.24	53.14	47.20
Ash	7.10	6.60	7.98	12.20	13 00	12.00	12.60	10.90	6.20	5.40	9.00	9.86	7.06	11.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Friable.	Light spongy.	Dense.	Dense.	Spongy.	Dense.	Friable.	Spongy.	Spongy.	Spongy.	Dense.	Spongy.	Dense spongy.	Spongy.
Color of the ash	Choco-late.	Lilac-grey.	Lilac-grey.	Lilac-grey.	Dark lilac-grey.	Dark lilac-grey.	Lilac-grey.	Dark lilac-grey.	Lilac-grey.	Dark brick.	Light lilac-grey.	Grey-purple.	Lilac-grey.	Dark-brown purple.
Per centage of sulphur	1.409	4.774	1.331	5.934	3.647	4.911	2.507	4.633	0.746	1.590	1.318	5.263	2.264	4.213

These comparative analyses show how much the coal of a given bed may vary in its different layers in the proportion of sulphur, ashes, &c. These Greenup county coals are generally very good coals, well suited to the working of iron. Some of them, however, are rather too sulphurous for this purpose.

A certain correspondence, not perfect, is to be observed in these coals, between their *specific gravity* and proportion of *ash*, as is shown below:

Specific gravity.	Per centage of ash.	Specific gravity.	Per centage of ash.
1.250	7.98	1.355	11.03
1.289	5.40	1.365	9.86
1.292	6.20	1.374	12.60
1.300	7.06	1.374	13.00
1.316	7.10	1.389	10.90
1.335	9.00	1.389	12.00
1.345	6.60	1.420	12.20

No. 1498—LIMESTONE. "*Average sample of the ferruginous limestone from Pea Ridge. Collected by J. A. Monroe.*"

A compact, or fine-granular, brownish-grey limestone. Non-fossiliferous. Varying in tint.

No. 1499—LIMESTONE. "*Sub-carboniferous; used as flux at the Raccoon Furnace. From the head of Old Town Creek.*"

A compact or fine-granular limestone, varying in color from light reddish-grey to darker greenish-grey. Contains chert.

No. 1500—LIMESTONE. "*Sub-carboniferous. Average sample of the limestone used as flux at Kenton Furnace. Collected by J. A. Monroe.*"

A compact or fine-granular limestone, of a light-grey color.

No. 1501—LIMESTONE. "*Ferruginous. Buffalo Creek, Boone Furnace.*"

A compact or fine-granular limestone; grey-buff, varying in tint.

COMPOSITION OF THESE GREENUP COUNTY LIMESTONES, DRIED AT 212° F.

	No. 1498.	No. 1499.	No. 1500.	No. 1501.
Specific gravity	.....	2.680	2.700	2.770
Lime carbonate	88.140	88.150	92.050	60.750
Magnesia carbonate	.797	.385	.220	25.656
Iron carbonate	.....	.....	.....	3.420
Alumina	.....	.....	.....	4.167
Iron peroxide	3.760	.152	1.490	.....
Manganese oxide				
Phosphoric acid	.178	.051	.128	.013
Sulphuric acid	.044	not est.	.199	.315
Potash	.269	not est.	not est.	not deter'd.
Soda	.240	not est.	not est.	not deter'd.
Silica and insoluble silicates	5.960	9.560	4.460	5.680
Loss	.612	1.702	1.453	.....
Total	100.00	100.00	100.000	100.001
Per centage of lime	49.358	49.359	51.548	34.020
Per centage of phosphorus	.077	0.022	.056	.005
Per centage of sulphur	.017	not est.	.079	.126

These limestones are quite pure enough and quite good for use as flux in the iron furnace. No. 1501 is a magnesian limestone. The proportions of phosphorus and sulphur are low in all of them. Nos. 1499 and 1500 would yield a very pure white lime on calcination.

No. 1502—CLAY IRON-STONE. *Labeled "Lower block ore, near the level of the limestone ore. Alcorn Creek, Raccoon Furnace."*

A fine-granular, dark-grey ore; adhering slightly to the tongue.

No. 1503—CLAY IRON-STONE. *Labeled "Blue kidney ore, locally replacing the main block ore; from drift one mile southeast from Laurel Furnace."*

A fine-granular ore, of a grey color more or less deep; with very thin incrustation of limonite ore. Some portions adhere to the tongue.

No. 1504 — CLAY IRON-STONE. *Labeled "Main block ore, Amanda Furnace. Averaged by P. N. Moore."*

A dark-grey granular proto-carbonate ore, with some dense irregular laminæ of limonite ore.

No. 1505—CLAY IRON-STONE. *Labeled "Conglomerate ore, on Darby branch of Clay Lick, Buffalo Furnace. Average sample."*

Principally grey granular proto-carbonate ore, with some limonite.

No. 1506—CLAY IRON-STONE. *Labeled "Lower block ore," Womack's bank ore, Old Town Creek. Sample from ore weathered six months. Collected by P. N. Moore.*

Mostly dense, dark-grey, fine-granular clay iron-stone, with some coarser grained and softer, with a little limonite.

No. 1507—CLAY IRON-STONE. *Labeled "Grey ore, or main block ore, Baker bank drift, Laurel Furnace. Averaged by P. N. Moore, from the stock pile. Identified by Mr. G. Coxe."*

Mostly proto-carbonate ore, containing many encrinital fossils, with some little limonite.

No. 1508—CLAY IRON-STONE. *Labeled "Grey ore from under the hearth rock sandstone, near Raccoon Furnace. Collected by P. N. Moore."*

Mainly brownish-grey fine-granular carbonate, with a whitish cement. Contains some little bituminous matter. Incrusted somewhat with reddish-brown limonite ore.

COMPOSITION OF THESE GREENUP COUNTY CLAY IRON-STONES, DRIED AT 212° F.

	No. 1502	No. 1503	No. 1504	No. 1505	No. 1506	No. 1507	No. 1508
Specific gravity	3.280	3.297	. . . .	. . . .	3.263	. . . .	. . . .
Iron carbonate	54.773	78.722	33.321	30.516	44.678	55.258	64.624
Iron peroxide	8.648	.204	21.270	14.271	6.500	13.468	4.044
Alumina	7.800	2.746	4.991	6.197	4.178	.670	4.414
Lime carbonate.	3.780	2.250	.980	16.980	2.230	4.880	1.340
Magnesia carbonate . . .	3.088	.380	.439	.591	1.903	4.528	.836
Manganese carbonate . .	1.204	.421	a trace.	a trace.	a trace.	.660	not est.
Phosphoric acid	.447	.505	.434	.614	.204	.368	.217
Sulphuric acid	.298	1.160	1.208	2.330	.250	1.043	.563
Silica and insol. silicates .	20.250	11.340	31.730	28.980	36.880	15.660	20.310
Water, bituminous matters, and loss	. . . .	2.272	5.627	. . . .	3.177	4.065	3.650
Total	100.288	100.000	100.000	100.429	100.000	100.000	100.000
Per centage of iron . . .	29.851	38.146	30.975	22.270	26.073	36.103	33.627
Per centage of phosphorus	.195	.221	.189	.267	.089	.209	.095
Per centage of sulphur .	.105	.524	.483	.905	.104	.416	.225
Per centage of silica . .	18.560	9.700	29.520	27.360	34.360	13.360	14.440

Some of the carbonate ores, which contain a larger proportion of iron peroxide, will be found described with the limonite ores. Phosphorus is in rather large proportion in Nos. 1502, 1503, 1504, and 1507, and sulphur exceeds in 1503, 1504, and 1505. Possibly some of this latter may be driven off in the process of roasting the ore. No. 1505, which contains the smallest proportion of iron, having nearly seventeen per cent. of carbonate of lime, may yet be profitably smelted, especially mixed with richer ores.

No. 1509—LIMONITE *"Limestone ore, Samuel Wamock's land, Tygert Creek. Bed one foot thick. Collected by A. R. Crandall. Not an average sample."*

Generally of a dark reddish-brown, varying to blackish and yellowish colors. In irregular laminæ. Adhering to the tongue.

No. 1510—LIMONITE. *Labeled "Average sample of lower Block ore, from branch of Tygert Creek."*

Varying in color, hardness, &c., from dark-brown, hard, irregular laminæ, to yellowish-red and brownish ochreous. Powder of a brownish-yellow color.

No. 1511 — LIMONITE (*with some proto-carbonate ore*); *labeled "Limestone ore, Hood's branch of Tygert's Creek. Average sample. Used at Raccoon Furnace."*

In irregular laminæ of various tints of yellowish and reddish brown, with some portions of clay iron-stone.

No. 1512—LIMONITE, &c. *"Average sample. Poynter bank. Raccoon Furnace."*

Dark brownish-red fragments, mixed some of clay iron-stone.

No. 1513—LIMONITE. *"Average sample of Two Lick 'Limestone ore,' Kenton Furnace. Averaged by P. N. Moore, from the stock pile."*

Generally of a dark-brown color, with incrustations of soft ochreous ore.

No. 1514—LIMONITE. *Labeled "Lower block ore," from Louder bank. Averaged by P. N. Moore.*

In irregular dark-brown laminæ, with softer ochreous and grey material intermixed and incrusting.

No. 1515—LIMONITE. *"Average sample of Coon Fork Limestone ore; taken from the unburnt kiln at Kenton Furnace by P. N. Moore, and identified by Mr. Folson."*

A dense, chocolate-red ore, scarcely adhering to the tongue. Contains some iron proto-carbonate.

No. 1516—LIMONITE. *Labeled "Shover drift Limestone ore. Average sample, by P. N. Moore, Kenton Furnace."*

A dense, chocolate-red colored ore, with but little ochreous material.

No. 1517—LIMONITE. *Labeled "Limestone ore. Powder Mill Hollow, Kenton Furnace."*

In irregular masses and laminæ of a chocolate-brown color, with soft ochreous ore between.

No. 1518—LIMONITE. *"Average sample of lower Block ore, from James Thompson's bank, Kenton Furnace. Collected by P. N. Moore."*

Laminæ of dense limonite, with softer ochreous material between, and some clay iron-stone in the interior.

No. 1519—LIMONITE. *Labeled "Lower Block ore. Average sample from Allen bank, Kenton Furnace. Collected by P. N. Moore."*

Irregular laminæ of hard dark brown limonite, with much brownish-yellow softer mineral between, and some whitish, clay-like substance, in the crevices.

No. 1520—LIMONITE, &c. *"Main Block ore, locally changed to a very calcareous ore, Buffalo Furnace. Averaged by P. N. Moore."*

Ore partly of yellowish-grey iron proto-carbonate of a crystalline-granular structure, not adhering to the tongue; in parts changed into dark reddish-brown limonite, which adheres to the tongue. Contains some small scales of mica and a few green specks (which may contain iron phosphide).

No. 1521—LIMONITE. *Labeled "Main Block ore, Little Morton bank, Laurel Furnace. Averaged by J. A. Monroe."*

In irregular curved laminæ of various thicknesses, differing in color, from dark clove-brown, almost black, to reddish and yellowish-brown; with nodules and incrustations of softer ochreous ore.

No. 1522—LIMONITE, &c. "*Average sample of Kidney ore, above the main Block ore. From the Buffalo Furnace stock pile. Collected by P. N. Moore.*"

Dense dark and light-brown limonite, with a little ochreous ore; mixed with compact or fine-granular grey clay iron-stone.

No. 1523—LIMONITE. "*Main Block ore, Brushy Knob bank, Laurel Furnace. Average sample, from the stock pile, by P. N. Moore.*" (*Determine only iron and silica.*)

Varying from hard dark-brown laminæ to brownish-yellow ochreous ore.

No. 1524—LIMONITE. "*Kidney ore, Osenton bank, Laurel Furnace. Averaged by P. N. Moore. Identified by Mr. G. Cox.*" (*Determine only the iron and silica.*)

Curved irregular laminæ of dense dark colored limonite ore, inclosing nodules of compact clay iron-stone.

No. 1525—LIMONITE. "*Rough ore, Darby branch of Clay Lick Creek. The upper of two lower block ores, Buffalo Furnace. Average sample, by P. N. Moore.*" (*Determine only the iron and silica.*)

Yellowish-brown limonite, mixed with grey iron proto-carbonate ore. Both showing an oölitic structure.

No. 1526—LIMONITE. "*Kidney block ore, or main Block ore. McAlister Point, Buffalo Furnace. Averaged by P. N. Moore.*"

Mostly in dark, purplish-brown, irregular, curved laminæ. (One small nucleus of partly decomposed clay iron-stone noticed.)

No. 1527—LIMONITE. "*Rough block ore; below the main Block ore, at Raccoon Furnace. Averaged by P. N. Moore.*"

Mostly in irregular, curved laminæ, with some softer ochreous ore included.

No. 1528—LIMONITE. *"Lower Block ore, on J. Downie's land, Old Town Creek. Averaged by P. N. Moore."*

Mostly porous, ochreous ore, with some dense limonite laminæ included.

No. 1529—LIMONITE. *"Limestone ore; called slate ore. Ridge between Cane Creek and Wilson Creek, Hunnewell Furnace. Average sample, by P. N. Moore."*

Mostly moderately dense, irregular laminæ, of a handsome brownish-purple color, with some ochreous ore.

No. 1530—LIMONITE. *Labeled "Lime kidney ore, Brush Creek, Pennsylvania Furnace. Average sample, by P. N. Moore."*

Principally in irregular curved laminæ, of a dark color; somewhat oölitic; inclosing, and incrusted with, some little undecomposed clay iron-stone.

COMPOSITION OF THESE GREENUP COUNTY LIMONITES, DRIED AT 212° F.

	No. 1509	No. 1510	No. 1511	No. 1512	No. 1513	No. 1514	No. 1515	No. 1516	No. 1517	No. 1518	No. 1519	No. 1520
Iron, peroxide	80.040	41.556	60.576	54.703	67.859	54.530	46.984	72.957	49.770	50.006	41.390	23.396
Iron, carbonate	. . . .	. . . .	15.623	17.758	. . . .	. . . .	7.890	. . .	. . . .	. . . .	. . . .	14.972
Alumina	2.680	8.604	2.860	2.300	1.160	2.120	5.580	1.660	6.315	8.317	6.777	4.077
Manganese, brown oxide	not est.	. . . .	. . . .	.440	.980	1.380	‡.572	.640	.640	a trace.	.180	‡.421
Lime carbonate	a trace.	.180	a trace.	.340	.120	.040	21.240	.380	.380	.380	a trace.	33.775
Magnesia	.425	not est.	.619	.499	1.275	1.823	2.904	.083	.115	.201	.065	‡968
Phosphoric acid	.115	.882	.632	.128	.143	.908	.371	.500	.166	.767	.579	.537
Sulphuric acid	.264	.851	not est.	.680	not est.	.336	not est.	.178	a trace.	.356	.154	.157
Alkalies	*.584	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Combined water	10.000	10.100	†7.040	†7.194	†12.903	10.900	†6.599	9.340	9.020	11.760	9.700	†5.457
Silex and insoluble silicates	6.560	38.160	12.650	15.958	15.560	28.360	7.860	15.160	33.200	28.820	40.380	16.240
Moisture and loss	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	.394	. . . .	.775	. . . .
Total	100.668	100.233	100.100	100.000	100.000	100.397	100.000	100.898	100.000	100.607	100.000	100.000
Per centage of iron	56.280	29.089	49.945	46.865	47.501	38.171	39.025	51.070	34.839	35.004	28.973	23.597
Per centage of phosphorus	.050	.358	.276	.055	.062	.428	.131	.218	.072	.339	.252	.224
Per centage of sulphur	.107	.310	not est.	.272	not est.	.134	not est.	.071	a trace.	.142	.061	.070
Per centage of silica	not est.	not est.	not est.	12.960	11.560	not est.	not est.	not est.	32.960	not est.	not est.	13.530

* Potash = 0.346; soda = 0.238. † And loss. ‡ Carbonates.

COMPOSITION OF THESE GREENUP COUNTY LIMONITES, DRIED AT 212° F.—Continued.

	No. 1521.	No. 1522.	No. 1523.	No. 1524.	No. 1525.	No. 1526.	No. 1527.	No. 1528.	No. 1529.	No. 1530.
Iron, peroxide	68.928	56.279	56.84	67.984	42.560	64.577	36.985	44.876	57.551	60.206
Iron, carbonate	.....	11.392	not deter'd.	not deter'd.	not deter'd.	.....	.....	.....	.....	not est.
Alumina	2.768	4.709	not deter'd.	not deter'd.	not deter'd.	not est.	5.508	4.083	6.017	1.044
Manganese, brown oxide	.290	a trace.	not deter'd.	not deter'd.	not deter'd.	1.360	.040	.260	.130	a trace.
Lime, carbonate	.680	.180	not deter'd.	not deter'd.	not deter'd.	.440	.520	.990	.150	.285
Magnesia	.641	.476	not deter'd.	not deter'd.	not deter'd.	.820	.533	.357	.758	.381
Phosphoric acid	.249	.601	not deter'd.	not deter'd.	not deter'd.	.172	.367	.166	.057	.161
Sulphuric acid	.748	.260	not deter'd.	not deter'd.	not deter'd.	.151	.116	.123	.105	.852
Combined water	11.100	*9.173	not deter'd.	not deter'd.	not deter'd.	*11.250	8.330	9.850	10.300	9.500
Silex and insoluble silicates	15.240	16.930	not deter'd.	not deter'd.	not deter'd.	21.230	46.760	39.080	25.450	25.930
Moisture, carb. acid, and loss	.....	.....	.....	.....	.....	.....	.841	.215	.....	1.641
Total	100.644	100.000	.....	.....	.....	100.000	100.000	100.000	100.518	100.000
Per centage of iron	48.249	44.896	39.788	47.589	29.792	45.204	25.889	31.413	40.285	42.144
Per centage of phosphorus	.098	.262	not deter'd.	not deter'd.	not deter'd.	.075	.160	.061	.025	.070
Per centage of sulphur	.299	.104	not deter'd.	not deter'd.	not deter'd.	.070	.046	.049	.042	.341
Per centage of silica	13.600	15.260	24.060	12.900	40.160	18.600	44.460	35.960	18.860	20.860

*And loss.

Although some of these ores contain too much phosphorus to make tough iron, they are generally good and profitable. The intelligent reader can estimate their relative value by this table.

[See Appendix for other Greenup county ores, &c.]

No. 1531—PIG IRON. "*Hot blast, No. 1 Foundry. Probably made in* 1872 *or* 1873, *Buffalo Furnace. Collected by P. N. Moore.*"

Quite a coarse-grained, brilliant, grey iron. Yields to the file; flattens a little under the hammer.

No. 1532—PIG IRON. "*Cold blast, No. 1 Foundry, Buffalo Furnace. Collected by P. N. Moore.*"

A moderately fine-grained, dark-grey iron, which yields easily to the file.

No. 1533—PIG IRON. "*Silver-grey hot blast iron. Made when working very hot, so that it is very cold-short. Buffalo Furnace. Collected by P. N. Moore.*"

A mottled, nearly white, silvery iron. Soft enough to yield to the file, but quite brittle. Scarcely flattening at all under the hammer.

No. 1534—PIG IRON. "*No. 1 Foundry, hot blast iron, Kenton Furnace. Collected by P. N. Moore.*"

A moderately coarse-grained, grey iron. Hard, but yields to the file. Extends considerably under the hammer.

No. 1535—PIG IRON. "*Hot blast, No. 1 Foundry iron; made at the fifth casting after thirty-six hours stoppage, on full burthen. The third casting gave grey iron. Collected by P. N. Moore.*"

A moderately coarse-grained, grey iron.

No. 1536—PIG IRON. "*No. 2, Foundry iron; from Hunnewell (formerly Greenup) Furnace. Collected by P. N. Moore.*"

A moderately coarse-grained, grey iron; very hard, but yields to the file. Extends considerably under the hammer.

COMPOSITION OF THESE GREENUP COUNTY PIG IRONS.

	No. 1531.	No. 1532.	No. 1533.	No. 1534.	No. 1535.	No. 1536.
Specific gravity . . .	6.825	6.944	6.872	6.897	7.117	7.041
Iron	91.656	94.739	88.106	92.724	91.668	92.368
Graphite	2.790	3.620	1.950	3.320	2.950	3.690
Combined carbon . .	a trace.	.780	.570	.660	. . . . .	. . . . .
Manganese	.084	.056	.014	.612	.332	.020
Silicon	4.106	.877	7.317	2.090	3.817	2.515
Slag	.600	.120	.900	.300	1.200	1.130
Aluminum	.399	.060	.165	.442	.128	.582
Calcium	.168	.104	.128	.184	.075	.048
Magnesium	.095	.082	.125	.190	.122	a trace.
Potassium	.086	.048	.048	.104	not est.	.056
Sodium	.016	.041	.002	.004	not est.	a trace.
Phosphorus	.695	.609	.768	.622	.334	.684
Sulphur	.150	.037	.019	.046	.041	.026
Total	100.845	101.173	100.112	101.298	100.667	101.119
Total carbon	2.790	4.400	2.520	3.980	2.950	3.690

[See Appendix for other pig irons of this county.]

No. 1537—SOIL. *"Surface soil, from near the top of Pea Ridge; two hundred and fifty feet above the railroad at Hunnewell, one and a half miles southwest of hill to east. 'Coaled land.' Has a second growth of oak, with a few maples, hickories, pines, &c. Above the limestone of Pea Ridge. Collected by J. A. Monroe."*

Soil of a dark yellowish-grey color. The coarse sieve (289 meshes to inch) removed from it some fragments of ferruginous sandstone.

No. 1538—SOIL. *Labeled "Sub-soil of the preceding, to eighteen inches below the surface, &c."*

Of a brownish-buff color; containing nearly half its weight of irregular fragments of ferruginous sandstone, with ferruginous concretions.

No. 1539—SOIL. *Labeled "Under clay to the two preceding, taken to three feet below the surface."*

Clay of a brownish-buff color, with lighter colored portions intermixed. Contains a considerable proportion of fragments of ferruginous sandstone and ferruginous concretions, but not quite so much as the preceding.

COMPOSITION OF THESE GREENUP COUNTY SOILS, DRIED AT 212° F.

	No. 1537.	No. 1538.	No. 1539.
Organic and volatile matters	5.050	4.030	5.105.
Alumina, Iron peroxide, Manganese, brown oxide	6.831	9.595	9.223.
Lime carbonate	a trace.	.123	.091
Magnesia	.116	.223	.034
Phosphoric acid	.089	.115	.192
Sulphuric acid	.058	.017	.019.
Potash	.217	.231	.312
Soda	.055	.097	.120.
Soluble silica	Not estimated.		
Sand and insoluble silicates	86.505	84.565	84.695.
Water expelled at 380° F.	1.000	.685	.615.
Loss	.079	.319	. . . . .
Total	100.000	100.000	100.406.
Moisture expelled at 212° F.	1.650	1.775	2.150.
Potash in insoluble silicates	Not estimated.		
Soda in insoluble silicates	Not estimated.		
Character of soil	Coaled land Surface soil	Sub-soil.	Under clay.

These soils are of medium good quality; they would be benefited by top-dressing with lime, and, if well drained, could be made quite productive by judicious management, the use of green crops, and other fertilizers. The surface soil is not as rich in the mineral fertilizers as the sub-soil and under clay.

HARDIN COUNTY.

No. 1540—SOIL. *"Forty-five years in cultivation. Taken to the depth of eight inches. Collected by C. S. Schenk."*

Farm of H. B. Helm; three thousand two hundred and fifty feet west from Elizabethtown, and sixteen hundred feet to the

right of the Elizabethtown and Paducah Railroad (facing Paducah), twenty feet above the rail. Slope 1:25. On limestone substratum. Timber: elm, sycamore, shell-bark hickory, hazelnut, sumach, sassafras, dogwood, &c. Rotation of crops: lately, two years in corn; one in oats, with three in clover, followed by two in wheat. Yield: of corn, thirty bushels; wheat, fifteen to twenty; of oats, twenty-five bushels to the acre. The land has been kept in good order and has had some straw manure.

Soil of a dark drab color. The coarse sieve (two hundred and eighty-nine meshes to inch) sifted out a little shot-iron ore and small fragments of ferruginous sandstone.

No. 1541—"SUB-SOIL *of the preceding; one thousand feet to the right of the railroad, and three thousand four hundred feet from Elizabethtown, on the Elizabethtown and Paducah Railroad Twenty feet above the rail. Taken to the depth of from eight to twelve inches. Collected by C. S. Schenk.*"

Of a lighter color than the preceding; greyish-buff. Contains some fragments of chert and small quartzose and ferruginous concretions.

No. 1542—"UNDER CLAY *to the two preceding, taken at a depth of from twelve to thirty-six inches. Collected by C. S. Schenk.*"

Of a lighter color than the preceding, and more yellowish. Contains some small fragments of weathered chert and ferruginous sandstone, and small concretions of oxides of iron and manganese.

No. 1543—"VIRGIN SOIL, *taken to the depth of eight inches. Farm of J. B. Bryan. Collected by C. S. Schenk.*"

Four thousand eight hundred feet west from Elizabethtown, on the Elizabethtown and Paducah Railroad, and twenty-eight hundred feet from the railroad. Thirty feet above the rail. Substratum, *limestone.* Timber: post oak, black and red oak, hickory, hazel, sumach, sassafras, and dogwood. The soil in

this neighborhood, cultivated carelessly, yields thirty-five bushels of corn to the acre.

Soil of a dark drab color. Contains a notable quantity of fragments of weathered chert and some of a fossil cyathophyllum.

No. 1544—"SUB-SOIL *of the preceding, from the depth of from eight to thirty-four inches. The limestone rock is thirty-six inches below the surface. Collected by C. S. Schenk.*"

Color lighter than that of preceding; of brownish-buff. Contains fragments of chert, more or less weathered, and of fossils.

No. 1545—"SOIL *of an old field, over forty years in cultivation without manure. Collected by C. S. Schenk.*"

Seven thousand two hundred and sixty feet west of Elizabethtown, on the Elizabethtown and Paducah Railroad, one thousand one hundred and forty-three feet to the left of that road, and ten feet above the level of the rail. Slope = 1:70. Sample to the depth of eight inches. Timber: same as the preceding. Rotation of crops: wheat, oats, clover, &c. Yields, when well managed, thirty bushels of corn, fifteen to sixteen of wheat, and twenty of oats, to the acre.

Soil of a dark drab color. Contains only a few small fragments (chips) of flint.

No. 1546—"SUB-SOIL *of the preceding, taken from eight to thirty-four inches from the surface. Collected by C. S. Schenk.*"

Sub-soil of a lighter and more yellowish color than the preceding; brownish-buff.

No. 1547—VIRGIN SOIL, *taken to the depth of eight inches. Collected by C. S. Schenk.*"

Field seven thousand two hundred and sixty feet west from Elizabethtown, eight hundred and thirty-seven feet to the left of Elizabethtown and Paducah Railroad, and ten feet above the level of the rail. Slope = 1:65. Has been cultivated one year in corn, producing forty bushels to the acre; has been

resting five years. Had no manure. Substratum limestone, at the depth of ten feet.

Soil of a dark drab color; contains no gravel, and very few small fragments of weathered chert and decayed vegetable roots.

No. 1548—"SUB-SOIL *of the preceding, taken at the depth of from ten to thirty-four inches. Collected by* C. *S. Schenk.*"

Sub-soil of a handsome brownish-salmon color.

No. 1549—"NEW SOIL, *to the depth of eight inches, farm of Daniel Klingelsmith's heirs. Collected by C. S. Schenk.*"

Eleven thousand three hundred and fifty feet west of Elizabethtown, on the Elizabethtown and Paducah Railroad, and two hundred and fifty feet to the north. Three feet above the level of the rail. Slope = 1:45. Substratum, limestone. Has been in cultivation five years. Rotation of crops: two years in corn; then one each in wheat, oats, and corn. Rented out land. No manure. Yields, of corn, thirty bushels; of wheat, twenty; and of oats, twenty-five bushels to the acre.

Soil of a brownish, dark-grey color. Contains no gravel.

No. 1550—"SUB-SOIL *to the preceding, taken at the depth of from eight to thirty-six inches from the surface. Collected by C. S. Schenk.*"

Sub-soil of a greyish-buff color. Contains some fragments of weathered chert.

No. 1551—"SOIL, *taken to the depth of eight inches, from an old field long in cultivation; rented out, and supposed to be worn out. Collected by C. S. Schenk.*"

Land of heirs of Daniel Klingelsmith, thirteen thousand eight hundred and eighty feet west from Elizabethtown, on Elizabethtown and Paducah Railroad; fifty feet to the right, on a level with the rail. Slope = 1:15. Rotation of crops: corn, wheat, oats, clover. Yields, of corn, seventeen bushels; of wheat, twelve; of oats, fifteen to sixteen bushels to the acre. No manure.

Soil of a brownish drab color. Contains some few small fragments of much weathered chert.

No. 1552—"SUB-SOIL *to the preceding, taken at from eight to thirty-nine inches from the surface. Collected by C. S. Schenk.*"

Color much like that of the preceding soil. No gravel or chert fragments sifted out.

No. 1553—"VIRGIN SOIL. *Woodland. Farm of Hayden English, sixty feet west of the four mile-post, on the Elizabethtown and Paducah Railroad; four feet above the level of the rail. Collected by C. S. Schenk.*"

Sample taken to the depth of twelve inches. Slope = 1:15. Timber: scrub oak, black oak, and black jack, generally of small size. Undergrowth: small sumach, sassafras, &c. Yield of such land is, of corn, eleven bushels; of wheat, six; of oats, eleven bushels to the acre.

Dry soil of a grey-buff color.

No. 1554—"SUB-SOIL *of the preceding, taken from twelve to twenty-six inches below the surface.*" *Collected by C. S. Schenk.*"

Dry soil of a lighter color and more yellowish than the preceding.

No. 1555—"NEW SOIL, *five years in cultivation, from farm of J. English. Collected by C. S. Schenk.*"

Sample taken to depth of eight inches, at a point two hundred and seventy feet west of the six mile-post, on the Elizabethtown and Paducah Railroad; twenty-one hundred feet to the left of the railroad, and at a level of ten feet above the rail. Slope = 1:75. Timber: black, white, red, and post oak, hickory, chestnut, &c. Rotation of crops: two years in corn, one each in oats, wheat, and corn. No manure. Yield of corn, thirty; of wheat, twelve; and of oats, twenty bushels to the acre.

Dried soil of a drab color.

No. 1556—"SUB-SOIL *of the preceding, taken at a depth of from eight to thirty-six inches. Collected by C. S. Schenk.*"

Dry sub-soil of a grey-buff color; lighter and more yellowish than preceding.

No. 1557—"SOIL *from an old field, forty-five years in cultivation. Snider's farm. Collected by C. S. Schenk.*"

Sample taken to the depth of eight inches, at a point thirteen hundred feet west of the six mile-post, on the Elizabethtown and Paducah Railroad, and twelve hundred and seventy feet to the left, at a level of ten feet above the rail. Slope 1:35. Section of the hole where the soil was taken: soil, eight inches; yellow clay, twenty-two inches; red clay, six inches. (The red clay land is considered best in this part of the State.) Roots penetrate to depth of eight feet, where the rock is found. Rotation of crops: corn, wheat, oats. Has been four years in pasture, and the last two years in grass. Yield: corn, twenty-two; oats, fifteen to sixteen; wheat, eight; potatoes, fifty-five; rye, ten bushels, and tobacco, eight hundred pounds to the acre.

Dried soil of a drab color.

No. 1558—"SUB-SOIL *of the preceding, taken at a depth of from eight to thirty-six inches. Collected by C. S. Schenk.*"

Dried sub-soil of a brownish-orange color.

No. 1559—"SOIL *of an old field, forty years or more in cultivation." Collected by C. S. Schenk.*"

Sample taken to the depth of six inches, at a point two hundred and fifty feet west of the nine mile-post (Long Grove Station). Three hundred and fifty feet to the right of the Elizabethtown and Paducah Railroad, at a level of twelve feet above the rail. Slope = 1:19. Timber, much like that in preceding soils of this county. Rotation of crops, for the last nine years: four in corn, one in wheat, with three in clover and one in wheat. No manure. Yield: corn, twenty-two; wheat, eight; oats, fifteen bushels to the acre.

Dried soil of a yellowish umber-grey color.

No. 1560—"SUB-SOIL *of the preceding, taken at from six to thirty-six inches from the surface. Collected by C. S. Schenk.*"

Dried sub-soil of a dark grey-buff color.

No. 1561—"SOIL *of an old field, farm of E. Hansborough. Collected by C. S. Schenk.*"

Sample taken to the depth of five inches, at a point one thousand three hundred and twenty-seven feet west of the three mile-post; eight and a quarter miles from Elizabethtown, on the Elizabethtown and Paducah Railroad; one thousand three hundred and fifty feet to the left of that road, and level with the rail. Slope = 1:24. Timber much like that on the preceding soils. Substratum limestone, at depth of forty-five inches. Rotation of crops: corn, wheat, oats, clover. No manure. Yield: corn, thirty; wheat, eighteen; oats, thirty; potatoes, forty bushels; tobacco, eight hundred to one thousand two hundred pounds to the acre. One of the best farms in this locality. Land kept in good order.

Dried soil darker than the next preceding, of a brownish-umber dark grey color.

No. 1562—SUB-SOIL *of the preceding. Sample taken from five to forty-five inches below the surface. Collected by C. S. Schenk.*"

Dried sub-soil of a light brick-red color. Somewhat adhesive.

No. 1563—"SOIL *of an old field, forty years in cultivation, without manure. Collected by C. S. Schenk.*"

Sample taken to the depth of ten inches, at a point two hundred feet to the right of the seven mile-post, Elizabethtown and Paducah Railroad; level five feet above the rail. Substratum limestone. Slope = 1:50. Rotation of crops: corn, wheat, oats, clover. Land kept in good order. Yield of corn, twenty-five; of wheat, twelve; of oats, twenty bushels to the acre.

Dried soil of a yellowish-umber color.

No. 1564—"SUB-SOIL *of the preceding, taken at a depth of from ten to thirty-eight inches. Collected by C. S. Schenk.*"

Dried sub-soil of a light yellowish-brick color. Somewhat adhesive.

No. 1565—"VIRGIN SOIL, *Woodland, on Hanson Duncan's farm. Collected by C. S. Schenk.*"

Sample taken to ten inches in depth, at a point seven hundred and sixty feet east of his house; about eighty feet below the Elizabethtown and Paducah Railroad at East View. Rock substratum—limestone.

Dried soil of a yellowish light-umber color.

No. 1566—"SUB-SOIL *of the preceding, taken at a depth of from ten to forty-six inches. Collected by C. S. Schenk.*"

Dried sub-soil of a light yellowish-brick color.

No. 1567—SOIL *from an old field, twenty-four years in cultivation. Collected by C. S. Schenk.*"

Sample taken to the depth of eight inches, at a point twelve hundred feet, north 50° east from Hanson Duncan's house; one hundred and seventeen feet below the railroad at East View Station. Slope = 1:26. Substratum limestone. Rotation of crops: 1. corn, 1. rye, 3. clover, 1. wheat. No manure. Yield: corn, thirty-five; wheat, seventeen; rye, six to seven bushels to the acre.

Dried soil of a yellowish light-umber color.

No. 1568—"SUB-SOIL *of the preceding, taken at a depth of from eight to forty inches. Collected by C. S. Schenk.*"

Dried sub-soil of a light yellowish-brick color.

No. 1569—"VIRGIN SOIL, *one year in cultivation, from sand land on Hanson Duncan's farm, near East View. Collected by C. S. Schenk.*"

Sample taken to the depth of four inches, at a point four hundred and twenty feet west of his house. Height level with

the roof of his house. Slope = 1:7. Substratum limestone. Timber about the same as described above. Land not much cultivated; considered too poor except for peaches, apples, &c.; but tobacco yields six hundred pounds to the acre.

Dried soil of a yellowish umber-grey; lighter colored than the preceding sample.

No. 1570—SUB-SOIL *of the preceding, taken at a depth of from four to thirty-six inches. Collected by C. S. Schenk.*"

Sub-soil of a light yellowish-brick color.

No. 1571—SOIL *from an old field, sixteen years in cultivation, on Hanson Duncan's farm, near East View. Collected by C. S. Schenk.*"

Sample taken to depth of six inches, at a point seven hundred and fifty feet, north 20° east from his house. Height, six feet above his house. Slope = 1:7. Substratum sandstone. In some years it has yielded eleven bushels of corn to the acre. Is now in orchard. Produces good peaches.

Dried soil of a yellowish light umber-grey color.

No. 1572—SUB-SOIL *of the preceding, taken at a depth of from six to thirty-four inches. Collected by C. S. Schenk.*"

Sub-soil of a light brick-color, varying in intensity. Contains many angular fragments of soft, friable, ferruginous sandstone.

NOTE.—For a continuation of this serial collection of soils, made on or near the line of the Elizabethtown and Paducah Railroad, by Mr. C. S. Schenk, see Grayson and Ohio counties.

COMPOSITION OF THESE HARDIN COUNTY SOILS, &c., DRIED AT 212° F.

	No. 1540.	No. 1541.	No. 1542.	No. 1543.	No. 1544.	No. 1545.	No. 1546.	No. 1547.	No. 1548.	No. 1549.	No. 1550.	No. 1551.	No. 1552.
Organic and vol. matters	3.675	2.600	2.650	2.950	2.500	3.100	2.025	3.300	3.035	4.150	2.750	3.535	3.150
Alumina, and iron and manganese oxides. .	5.790	8.617	10.775	5.786	9.705	6.905	9.190	7.705	11.624	6.865	8.870	8.784	11.900
Lime carbonate . .	.160	.195	.110	.195	.145	.245	.195	.295	.110	.495	.245	.230	.175
Magnesia	.250	.431	.158	.375	.240	.258	.140	.339	.267	.501	.284	.152	.321
Phosphoric acid . . .	.160	.123	.115	.119	.125	.204	.125	.156	.216	.108	.134	.156	.108
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash (ext'ed by acid)	.154	.188	.265	.404	.462	.308	.327	.193	.256	.209	.399	.159	.150
Soda (extracted by acid)	.109	.002	.030	.030	.035	.033	.037	.027	.160	.079	.054	.026	.140
Sand and insol. silicates	88.590	86.975	84.740	89.555	85.925	87.465	86.840	86.815	83.925	86.590	86.640	86.215	83.315
Water expel'd at 380° F.	1.235	.925	.750	.900	.850	1.100	.725	1.050	.600	1.250	.850	.800	.700
Loss	. . . .	. . . .	.407	.186	.013	382	396	.120	. . . .	. . . .	. . . .	. . . .	.041
Total	100.123	100.056	100.000	100.000	100.000	100.000	100.000	100.000	100.193	100.247	100.226	100.057	100.000
Hygroscopic moisture .	1.510	1.575	2.140	1.125	1.650	1.325	1.700	1.500	1.800	1.650	1.875	1.650	2.200
Potash in insol. silicates	0.803	not est.	not est.	0.617	0.798	0.977	not est.	not est.	not est.	not est.	not est.	0.864	not est.
Soda in insol. silicates.	.467	not est.	not est.	0.188	0.406	0.280	not est.	not est.	not est.	not est.	not est.	.444	not est.
Character of soil . . .	Old field soil.	Sub-soil.	Under clay.	Virgin soil.	Sub-soil.	Old field.	Sub-soil.	Virgin soil.	Sub-soil.	New soil.	Sub-soil.	Old field.	Sub-soil.

COMPOSITION OF THESE HARDIN COUNTY SOILS, &c., DRIED AT 212° F.—(Continued.)

	No. 1553	No. 1554	No. 1555	No. 1556	No. 1557	No. 1558	No. 1559	No. 1560	No. 1561	No. 1562	No. 1563	No. 1564
Organic and volatile matters . .	1.950	1.990	2.185	2.135	2.100	2.935	2.625	2.525	3.215	3.785	3.080	2.785
Alumina, and iron and manganese oxides	5.926	8.344	5.692	9.476	6.359	12.798	7.388	10.445	6.790	15.763	6.564	10.763
Lime carbonate	.130	.080	.270	.220	.220	.220	.190	.120	.370	.620	.445	.495
Magnesia	.167	.204	.213	.208	.050	.194	.095	.362	.189	.095	.213	.282
Phosphoric acid	.076	.093	.070	.134	.093	.124	.124	.120	.172	.124	.123	.124
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash (extracted by acid) . . .	.163	.298	.250	.313	.223	.342	.221	.339	.202	.421	.293	.212
Soda (extracted by acid)	.005	.120	.037	.045	.023	.033	.026	.260	.049	.101	.050	.219
Sand and insoluble silicates. . .	90.465	88.115	89.965	86.240	89.790	82.165	88.090	85.140	87.765	77.375	87.975	84.290
Water expelled at 380° F. . . .	.935	.775	1.425	.900	.950	.975	1.150	.950	1.400	1.515	1.235	1.135
Loss	.183	. . . .	. . . .	.329	.192	.214	.091	. . . .	. . . .	.201	022	. . . .
Total	100.000	100.019	100.107	100.000	100.000	100.000	100.000	100.261	100.152	100.000	100.000	100.305
Hygroscopic moisture	1.585	2.200	1.400	2.400	1.485	2.650	1.385	2.450	1.600	3.860	1.300	1.375
Potash in the insoluble silicates .	1.140	not est.	not est.	not est.	0.560	not est.	0.675	not est.	1.148	.974	not est.	not est.
Soda in the insoluble silicates . .	.641	not est.	not est.	not est.	.373	not est.	.339	not est.	.731	.420	not est.	not est.
Character of the soil	Virgin soil.	Sub-soil.	New soil.	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.	Old field.	Sub-soil.

COMPOSITION OF THESE HARDIN COUNTY SOILS, &c., DRIED AT 212° F.—(Continued.)

	No. 1565.	No. 1566.	No. 1567.	No. 1568.	No. 1569.	No. 1570.	No. 1571.	No. 1572.
Organic and volatile matters	3.215	4.400	3.050	2.575	2.600	2.225	2.165	2.575
Alumina, and iron and manganese oxides	5.365	6.395	5.550	5.828	4.465	7.015	2.740	6.900
Lime carbonate	.445	.270	.305	.236	.170	.080	.180	.045
Magnesia	.168	.205	.240	.078	.176	.104	.087	.068
Phosphoric acid	.172	.045	.102	.112	.147	.134	.067	.102
Sulphuric acid	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.	a trace.
Potash (extracted by acid)	.188	.202	.173	.183	.212	.202	.135	.183
Soda (extracted by acid)	.041	.050	a trace.	.053	.055	.076	.072	.045
Sand and insoluble silicates	87.940	88.425	89.290	90.470	91.790	89.855	94.290	89.940
Water expelled at 380° F.	1.525	.650	1.100	.475	.775	.450	.550	.225
Loss	.841	. . . . .	190	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Total	100.000	100.742	100.000	100.010	100.390	100.141	100.286	100.083
Hygroscopic moisture	1.890	1.800	1.690	2.360	1.225	1.900	0.800	2.075
Potash in the insoluble silicates	1.550	not est.	not est.	not est.	1.332	. . . . .	0.869	0.485
Soda in the insoluble silicates	.350	not est.	not est.	not est.	.444	. . . . .	.236	.165
Character of the soil	Virgin soil.	Sub-soil.	Old field.	Sub-soil.	Virgin soil.	Sub-soil.	Old field.	Sub-soil.

For the other soils of this series, collected along the line of the Elizabethtown and Paducah Railroad by Mr. C. Schenk, see Grayson and Ohio counties. The remarks appended to the Grayson county soils will apply to these with some obvious local variations.

HENRY COUNTY.

No. 1575—GALENA. "*From Roberts' lode, north opening. Carefully averaged, by Prof. N. S. Shaler.*"

Cubical and granular galena, disseminated in white, compact, baryta sulphate; with some zinc blende (zinc sulphide).

The galena was selected from the mixed lumps, simply for assaying to determine the presence or proportion of silver.

No. 1576—GALENA "*From Roberts' lode, south opening, &c.*

Like the preceding; but containing a larger proportion of galena. The galena was *selected* from the lumps for analysis.

Fused with the usual flux of carbonate of soda, nitrate of potash and salt; the former, No. 1575, gave 72.70 to 76.585 per cent. of lead; the latter, No. 1576, gave about seventy-one and a half per cent. This does not of course represent all the lead existing in the selected galena, but is supposed to contain all the silver.

The well washed lead buttons were dissolved, severally, in dilute nitric acid; and to the very much diluted solutions a solution of lead chloride was added.

The former, No. 1575, gave a faint precipitate of silver chloride on standing—not enough to justify its extraction; the latter gave no sensible precipitate of the silver chloride. These ores seem, therefore, to be too poor in silver to pay for its extraction.

Another specimen of lead ore, from an unopened lode, on Mill branch of Six Mile Creek, contained so small a proportion of galena to the baryta sulphate that it was not thought proper to analyze it.

No. 1577—MARLY SHALE *or indurated marl.* "*Cut of the Cumberland and Ohio Railroad, Eminence, Henry county. Collected by Prof. N. S. Shaler.*"

An olive-grey, indurated marl; containing nodules of chætetes, and portions of other Silurian fossils.

COMPOSITION, DRIED AT 212° F.

Silica	23.700
Alumina	7.146
Iron and manganese oxides	11.040
Lime carbonate	44.560
Magnesia	.310
Phosphoric acid	1.164
Sulphuric acid	.961
Potash	2.100
Soda	.623
Water expelled at red heat, and loss	8.396
Total	100.000

The large proportions of lime, potash, phosphoric acid, &c., in this marly shale, would doubtless make it valuable as a top-dressing on exhausted light soils; but it is not rich enough in the mineral fertilizers to justify much expenditure for transportation.

HOPKINS COUNTY.

No. 1578—COAL. "*Mr. Wm. Mills' coal, just partially opened. Nortonsville, Hopkins county. Collected by C. J. Norwood. (Probably not a fair average sample.*")

Generally a jet-black, glossy coal; breaks in part in thin layers, with some compressed fibrous coal between. Some thin laminæ of pyrites apparent. (Specimen seems to contain an inordinate proportion of pyrites.)

No. 1579—COAL. "*St. Charles Mines. Average sample, by C. J. Norwood.*" (*Coal D.*)

A jet-black, glossy coal; iridescent in parts. Some fibrous coal between the laminæ, and but little appearance of pyrites.

COMPOSITION OF THESE HOPKINS COUNTY COALS, AIR-DRIED.

	No. 1578.	No. 1579.
Specific gravity	1.448	1.322
Hygroscopic moisture	3.40	3.20
Volatile combustible matters	30.00	35.90
Coke	66.60	60.90
Total	100.00	100.00
Total volatile matters	33.40	39.10
Carbon in the coke	51.10	54.00
Ashes	15.50	6.90
Total	100.00	100.00
Character of the coke	Spongy.	Light spongy.
Color of the ash	Dark grey-purple.	Light lilac-grey.
Per centage of sulphur	7.280	2.759

No. 1579 is a very good coal, containing but little earthy matter and a moderate proportion of sulphur. The other exceeds the average proportions of these; but is not probably a fair sample. It is well known that coal beds vary greatly in their different layers; and this may prove to be a good coal when the bed is fairly opened.

No. 1580—"LIMONITE, *ochreous, from near St. Charles Mines, Mr. Norton's land. On the working coal. Collected by C J. Norwood.*"

Flat kidney-form concretions, of a handsome brownish-yellow color, of different shades. Easily scratched with the nail; adheres to the tongue.

COMPOSITION, DRIED AT 212° F.

Iron peroxide	50.850
Alumina	5.462
Manganese oxide	a trace.
Lime carbonate	3.129
Magnesia	1.546
Phosphoric acid	.198
Sulphuric acid	.189
Water expelled at red heat	10.530
Silica and insoluble silicates	27.680
Loss	.416
Total	100.000
Per centage of iron	35.595
Per centage of sulphur	.075
Per centage of silica	22.220
Per centage of phosphorus	.086

This is rich enough to be smelted for iron, and might make a good ochre pigment on grinding.

KENTON COUNTY.

No. 1581 — "SILICIOUS GRIT *at first toll-gate, two miles from Covington, on Lexington Turnpike. Collected by Prof. N. S. Shaler.*"

A brownish-grey, ferruginous impure sandy mass.

No. 1582—"SILICIOUS GRIT *from same locality as preceding. Used for moulding sand. Collected by Prof. N. S. Shaler.*"

An impure, reddish-brown friable sandy mass; infiltrated with iron oxide; varying in tint from grey to deep brown. The sand grains are rounded.

COMPOSITION OF THESE KENTON COUNTY GRITS, DRIED AT 212° F.

	No. 1581.	No. 1582.
Silica	77.460	75.700
Alumina, and iron and manganese oxides	16.500	15.793
Lime carbonate	.480	.660
Magnesia	.121	.214
Potash	.828	.847
Soda	.580	.762
Phosphoric acid	not est.	.639
Sulphuric acid	not est.	not est.
Water expelled at red heat	4.500	5.100
Total	100.469	99.716

The amount of alkalies contained in these impure sands is somewhat remarkable. They exist in them, however, mostly in the silicates which are insoluble in acids; and were separated in the analyses, by the process of fusion with the mixture of lime carbonate and ammonium chloride, &c., according to the method of J. Lawrence Smith. Notwithstanding the unavailable condition of these alkalies, these sands might prove useful additions to heavy clay soils, more especially because of their notable proportion of phosphoric acid. For this purpose, however, they could only be employed in the close vicinity of their beds, as they would not pay for long transportation.

No. 1583—"CLAY, *supposed to be in the Cincinnati Group of the Lower Silurian formation. Lexington Turnpike, two miles south of Covington. Top section just below that of the preceding grits. Collected by Prof. N. S. Shaler.*"

A laminated or shaly clay of handsome light-buff and bluish-grey colors, alternating.

No. 1584—CLAY. "*Clay-pit at brick-yard. Head of Russel street, Covington. Average of the nine-feet section. Collected by Prof. N. S. Shaler.*"

A yellowish ferruginous clay; mottled with light bluish-grey; containing fine silicious grains.

No. 1585—MARLY SHALE. *"Junction of the Ohio and Licking rivers, twelve feet above low water mark. Cincinnati (Hudson River) Group. Collected by Prof. N. S. Shaler."*

A fine-grained, dark-grey shale; dull; adhering somewhat to the tongue.

No. 1586—MARLY SHALE. *Labeled "Fine shales, between impure limestone; five feet above low water mark. Whitehall. No fossils. Collected by Prof. N. S. Shaler."*

A soft friable shale; dark-grey in the fresh fracture; adhering to the tongue.

COMPOSITION OF THESE KENTON COUNTY MARLY CLAYS AND SHALES DRIED AT 212° F.

	No. 1583.	No. 1584.	No. 1585.	No. 1586.
Silica	56.400	68.360	43.461	47.160
Alumina, and iron and manganese oxides	29.971	22.256	21.000	22.850
Lime carbonate	.760	1.000	27.040	20.140
Magnesia	1.514	1.181	.680	.840
Phosphoric acid	.166	.258	.607	.128
Sulphuric acid	not est.	not est.	not est.	not est.
Potash	3.538	2.139	2.447	2.301
Soda	.551	.906	.915	1.590
Water expelled at red heat	7.100	3.650	3.850	5.200
Total	100.000	99.750	100.000	100.209

These marly shales would undoubtedly be valuable for top-dressing poor light soils in their vicinity, notwithstanding most of their alkaline ingredients are in a state of combination which renders them, for the present, unavailable for plant nourishment. The gradual action of the atmospheric agencies and of humus, as well as that of the lime, will eventually bring them into a soluble state. The latter two may be considered the best for this purpose.

No. 1587—LIMESTONE. *Labeled "Blue argillaceous limestone. Low water mark. Whitehall, near Covington. Collected by Prof. N. S. Shaler."*

A fine-grained, dark-grey limestone. Not adhering to the tongue.

COMPOSITION, DRIED AT 212° F.—SPECIFIC GRAVITY = 2.720.

Lime carbonate	64.240	= 35.974 per cent. of lime.
Magnesia carbonate	6.152	
Alumina, and iron and manganese oxides	4.960	
Phosphoric acid	.191	
Sulphuric acid	not est.	
Potash	.643	
Soda	.260	
Silex and insoluble silicates	23.860	
	100.306	

This limestone, like most of the layers of the Lower Silurian limestone (or blue limestone, so-called), is, in consequence of its large proportions of alkalies and phosphoric acid, peculiarly suited to agricultural purposes. The use of this lime, in the calcined state, upon our old fields, if properly managed and applied just before the clover crop, in a rotation, would doubtless be quite beneficial in restoring fertility.

LAWRENCE COUNTY.

No. 1588—"COAL. *No.* 3, "*From McHenry's coal bank, six miles south of Louisa. Average sample, by A. R. Crandall.*"

A jet-black coal, with very little fibrous coal and no appearance of pyrites.

No. 1589—"COAL. *No.* 1, *from F. Swetman's bank, Brushy Creek. Collected by A. R. Crandall.*"

A jet-black coal, with some little external earthy or ferruginous staining, and but little fibrous coal or pyrites.

No. 1590—COAL. *No.* 1, "*From near Henderson, Boggs' Mill, Cane's Creek. Collected by A. R. Crandall.*"

Rather a dull-black coal, breaking into thin laminæ, with fibrous coal between, but with little appearance of pyrites. Some external ferruginous stain.

No. 1591—COAL. *No.* 3. "*Holbrook's coal, Brushy Creek. Collected by A. R. Crandall.*"

Rather a dull-black coal, breaking into thin laminæ, with fibrous coal between, but with little appearance of pyrites.

No. 1592—COAL. *No. 3. "Mr. Boggs' bank, one mile from mouth of Cane's Creek. Upper portion of the coal. Collected by A. R. Crandall."*

A jet-black coal, with some fibrous coal between the laminæ, but with little appearance of pyrites.

No. 1593—COAL. *No. 3. "Mr. Boggs' bank, &c., &c. Lower portion of the coal. Collected by A. R. Crandall."*

Breaking into thin laminæ, with fibrous coal between. Some external ferruginous incrustation.

COMPOSITION OF THESE LAWRENCE COUNTY COALS, AIR-DRIED.

	No. 1588	No. 1589	No. 1590	No. 1591	No. 1592	No. 1593
Specific gravity	1.316	1.281	1.376	1.349	1.350	1.284
Hygroscopic moisture	4.60	5.10	3.30	2.10	2.50	2.50
Volatile combustible matters	35.70	35.30	35.16	33.90	38.56	39.00
Coke	59.70	59.60	61.54	64.00	58.94	58.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.30	40.40	38.46	36.00	41.06	41.50
Carbon in the coke	53.28	57.80	47.84	56.00	51.44	54.76
Ashes	6.42	1.80	13.70	8.00	7.50	3.74
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Light spongy.	Dense spongy.	Friable.	Light spongy.	Spongy.
Color of the ash	Light lilac-grey	Light grey-buff.	Dark lilac-grey	Yellowish-white	Grey-purple.	Brownish grey.
Per centage of sulphur	1.080	0.736	2.109	0.736	3.785	1.066

With one or two exceptions, as is readily to be seen, these are remarkably good and pure coals, which will compare favorably with the best Ohio and Indiana coals.

It is interesting to notice in the above table the nearly constant relation of the specific gravity to the relative proportion of ash, to-wit:

In No.	1589	the specific gravity is	1.281;	per centage of ash =		1.80.
"	1593	" "	1.284;	"	"	3.74.
"	1588	" "	1.316;	"	"	6.42.
"	1592	" "	1.350;	"	"	7.50.
"	1591	" "	1.349;	"	"	8.00.
"	1590	" "	1.376;	"	"	13.70.

This relation of the specific gravity to the proportion of the ash is not constant in coals generally.

No. 1594—RED HEMATITE *"Found on top of hill near Louisa, Lawrence county. By A. R. Crandall."*

Nodular lumps, of various sizes, of very hard, dense, dark colored ore, with hardly any soft ochreous material. Powder of a brownish-red or maroon color.

COMPOSITION, DRIED AT 212° F.—SPECIFIC GRAVITY = 4.184.

Iron peroxide	80.004 =	56.028 per cent. of iron.
Alumina	3.474	
Manganese, brown oxide	.250	
Lime	.360	
Magnesia	.396	
Phosphoric acid	.172 =	0.075 per cent. of phosphorus.
Sulphuric acid	.055 =	.020 per cent. of sulphur.
Silica and insoluble silicates	14.200 =	13.500 per cent. of silica.
Water and loss	1.089	
	100.000	

The red hematite is an exceptional ore in the coal measures, but is found in abundance in the Clinton Group.

LIVINGSTON COUNTY.

No. 1595—GALENA. *"From Royall Mines, Mineral Point, Cumberland river. Taken one hundred and twenty-five feet from the surface; sloping away from the river. Collected by Prof. N. S. Shaler."*

The galena is mingled with colorless and violet-colored fluor-spar.

No. 1596—GALENA. *"From same mines, taken forty-five feet from the surface, &c., &c."*

The galena, separated from the gangue, of both these samples, was reduced by the usual flux and tested for silver.

No. 1595 gave a button of lead weighing 79.34 per cent. of the weight of the galena, and No. 1596 one which weighed 79.052 per cent.

These were severally dissolved in diluted nitric acid and tested for silver by the addition of the watery solution of lead chloride to the diluted nitrate of lead solution; and in neither case was more than a minute trace of silver chloride obtained. So that these galenas cannot be profitably worked for the extraction of silver.

LYON COUNTY.

No. 1597—"LIMONITE *iron ore from old Suwannee Furnace, Big Showing. Sub-carboniferous. Collected by P. N. Moore.*"

A dense, dark-brown limonite, in irregular laminæ, with a small amount of investing soft ochreous ore.

No. 1598—LIMONITE. "*Old Suwannee Furnace. Bank close to the furnace. Sub-carboniferous. Collected by P. N. Moore.*"

A dense, dark-brown ore, in irregular laminæ, with some brown hematite and soft ochreous ore. Some cherty nodules.

No. 1599—"LIMONITE, *with occasional thin layers of brown hematite. Old Suwannee Furnace property. Railroad cut. Sub-carboniferous formation. Average sample of the ore in the railroad cut. Collected by P. N. Moore.*"

A dense, dark-brown limonite, with thin incrustations of brown hematite and some soft ochreous ore.

No. 1600—LIMONITE. "*Old Suwannee Furnace property. Iron Mountain bank. Sub-carboniferous. Average sample, by P. N. Moore.*"

Generally in dark-brown irregular laminæ, with some yellowish and brownish ochreous ore, and occasional small nodules of chert.

COMPOSITION OF THESE LYON COUNTY LIMONITES, DRIED AT 212° F.

	No. 1597.	No. 1598.	No. 1599.	No. 1600.
Iron peroxide	59.370	70.518	66.117	69.392
Alumina	1.622	.045	1.064	a trace.
Manganese, brown oxide	.090	.190	.170	.170
Lime carbonate	.170	.090	.090	.140
Magnesia	.100	a trace.	a trace.	a trace.
Phosphoric acid	.179	.275	.434	.303
Sulphuric acid	.508	.113	.213	a trace.
Water expelled at red heat	8.400	9.850	9.800	9.550
Silica and insoluble silicates	30.000	18.910	22.330	20.500
Moisture and loss	.....	.009	.....	.....
Total	100.439	100.000	100.218	100.055
Per centage of iron	41.559	49.363	46.819	48.574
Per centage of phosphorus	.077	.120	.189	.144
Per centage of sulphur	.212	.045	.083	.....
Per centage of silica	26.800	18.160	21.160	19.660

In volume 4 of *Reports of Kentucky Geological Survey*, old series, may be found the amount of the analyses of other materials from this old furnace, beginning at page 209.

Quite rich ores, and very good, except those which show a large proportion of sulphur or phosphorus.

For an account of the analysis of the water contained in the interior of a geode of "pot ore," see the Appendix.

MENIFEE COUNTY.

No. 1601—COAL. "*Sub-conglomerate, forty feet above the sub-carboniferous limestone. Hawkins' Creek, near the line of Powell county. Menifee county. Average sample, collected by A. R. Crandall.*"

No. 1602—COAL. "*Sub-conglomerate, forty to forty-five feet above the sub-carboniferous limestone, near the mouth of Glady Creek, on Ledford's land. A thin bed. Collected by A. R. Crandall.*"

No. 1603—BITUMINOUS SHALE. "*Sub-conglomerate (mistaken for coal). Twenty to twenty-two feet thick; immediately above the sub-carboniferous limestone. Average sample, by A. R. Crandall.*"

A friable shale, resembling some kinds of cannel coal, of a dull brownish-black, with some thin ferruginous incrustation. Fracture irregular; sub-conchoidal.

COMPOSITION OF THESE COALS AND THE SHALE, AIR-DRIED.

	No. 1601.	No. 1602.	No. 1603.
Specific gravity	1.319	not est.	not est.
Hygroscopic moisture	2.94	2.66	2.80
Volatile combustible matters	33.06	34.04	15.20
Coke (or fixed residue)	64.00	63.30	82.00
Total	100.00	100.00	100.00
Total volatile matters	36.00	36.70	18.00
Carbon in the coke, &c.	56.60	50.24	24.30
Ashes	7.40	13.06	57.70
Total	100.00	100.00	100.00
Character of the coke, &c.	Dense.	Dense.	Pulverulent
Color of the ash	Light brownish-grey.	Dark lilac-grey.	White.
Per centage of sulphur	0.997	4.092	not est.

Some of the sub-conglomerate coals are found to be quite good. The bituminous shale described above, however, hardly contains enough combustible matters (having only eighteen per cent.) to make it available for fuel.

Samples of various rocks and minerals were brought to the laboratory by Mr. J. M. Vanarsdall, from this county, from the vicinity of Glady Creek; consisting of iron ores, pyrites, marly clay, zinc sulphide, &c., with some small globules of a white metal which he obtained from the ashes of the furnace of the

so-called "James Kirk's silver mine." The metal contained tin and copper, and the furnace was probably used by counterfeiters, who, selecting out-of-the-way regions for their operations, seem frequently to conceal the character of them by the pretense of working a silver mine.

This county has not as yet been thoroughly examined by the Geological corps; and doubtless contains much more mineral wealth than is indicated by these few analyses here reported.

MONTGOMERY COUNTY.

No. 1604—"QUICKLIME. *Star Lime Company's lime. Burnt at (or near) Mt. Sterling. Obtained from Williamson & Bro., Lexington.*"

Not remarkably white, presenting an oölitic structure in some of the pieces.

COMPOSITION.

Lime	98.301
Magnesia	.092
Alumina, and iron and manganese oxides	.747
Phosphoric acid	.023
Sulphuric acid	not est.
Potash	.012
Soda	.011
Silica and insoluble silicates	.814
Total	100.000

This analysis, made by the youngest son of the writer (Alfred M. Peter) under his inspection, indicates a degree of purity which fits this lime for all purposes of construction, except, perhaps, for the whitest finishing coats in plastering.

MUHLENBURG COUNTY.

No. 1605—LIMONITE *Labeled "Iron ore from near No. 4 entry. Airdrie Furnace. Averaged by P. N. Moore."*

A porous, yellowish, and deep brown ore.

No. 1606—LIMONITE. *"Iron ore from Jerry M. Hope's land, near Muddy river. Average sample, by P. N. Moore, of the surface limonite from the upper part of the bed."*

A cellular limonite (fossiliferous), of a bright yellowish-brown color externally, with darker, hard, curved laminæ included.

No. 1607—LIMONITE. *"Ore from the lower and middle parts of the bed. Jerry Hope's land, &c., &c. Average sample, by P. N. Moore."*

A porous, brownish-yellow, fossiliferous ore.

No. 1608 — LIMONITE. *"Martin ore from near Greenville. Average sample, by P. N. Moore."*

A cellular limonite, with ochreous incrustation, &c.

No. 1609—"ROASTED ORE *from the Airdrie Furnace stock pile. Has been weathered seventeen years since roasting. Collected by P. N. Moore."*

Apparently a "Black-band ore," so-called, originally. The roasted ore is of a dark, reddish-brown color, varying to lighter tints. Some portions are cellular, as though they had been fused.

COMPOSITION OF THESE MUHLENBURG COUNTY LIMONITE IRON ORES, &c., DRIED AT 212° F.

	No. 1605.	No. 1606.	No. 1607.	No. 1608.	No. 1609.
Specific gravity	3.246	.....	.....	.....	3.652
Iron peroxide	63.048	60.492	46.865	69.546	59.810
Alumina	5.290	7.075	5.930	3.914	2.972
Brown oxide of manganese	.090	.360	.103	.230	.720
Lime carbonate	.680	1.980	2.535	.480	*2.263
Magnesia	.930	1.550	1.073	.921	4.270
Phosphoric acid	.147	.083	.179	.115	.223
Sulphuric acid	.112	.185	.059	.216	.065
Water expelled at red heat	12.430	12.530	9.550	11.250	.200
Silex and insoluble silicates	17.250	15.560	33.530	12.730	29.880
Moisture and loss	.....	.185	.175	.598	.....
Total	100.077	100.000	100.000	100.000	100.403
Per centage of iron	44.133	42.344	32.806	48.822	41.867
Per centage of phosphorus	.064	.035	.078	.050	.097
Per centage of sulphur	.044	.074	.024	.086	.026
Per centage of silica	16.500	13.660	32.860	11.300	25.260

*Lime.

These Airdrie Furnace limonites are all good and profitable ores, which would yield a good quality of iron if properly smelted, as they contain but a moderate proportion of the injurious ingredients, phosphorus and sulphur. Although it is probable that the "roasted ore" was from the so-called "Black-band ore" (bituminous clay iron-stone), it is properly tabulated with these limonites. The analyses of other similar iron ores from this region are detailed in the previous volumes of Kentucky Geological Reports. (*See volume* 1, *pages* 345 *and* 346, *and volume* 4, *page* 229.)

No. 1610—CLAY IRON-STONE. *Bituminous. So-called "Black-band" ore. From the Airdrie Furnace stock pile; weathered seventeen years. Not roasted. Collected by P. N. Moore."*

A shaly ore, varying in color, in layers, from nearly black to dark grey-brown.

No. 1611 — CLAY IRON-STONE. *Bituminous. Labeled "Slate iron ore, from Buckner Furnace. Weathered thirty years. Average sample, by P. N. Moore."*

A Black-band ore, of a dark umber-brown color, varying in tint. Shaly, and containing carbonaceous matter.

No. 1612—CLAY IRON-STONE *"From the lower part of the bed at Jerry Hope's bank, near Muddy river. Collected by P. N. Moore."*

A rough, greenish and brownish, fossiliferous and silicious carbonate ore.

COMPOSITION OF THESE CLAY IRON-STONES, DRIED AT 212° F.

	No. 1610.	No. 1611.	No. 1612.
Specific gravity	3.376	not deter'd.	not deter'd.
Iron carbonate	47.810	42.950	26.643
Iron peroxide	9.054	29.618	18.374
Alumina	5.205	2.454	6.548
Lime carbonate	3.740	2.490	13.430
Magnesia carbonate	7.180	4.828	5.698
Manganese carbonate	.797	1.083	a trace.
Phosphoric acid	.179	.083	.211
Sulphuric acid	.237	1.596	.185
Silica and insoluble silicates	17.010	9.030	22.230
Water, bituminous matter, and loss	8.788	5.868	6.681
Total	100.000	100.000	100.000
Per centage of iron	29.418	36.916	27.136
Per centage of phosphorus	.078	.035	.092
Per centage of sulphur	.094	.638	.074
Per centage of silica	12.900	6.220	20.660

These clay iron-stones are not very rich in iron, except the one (No. 1611) from Buckner Furnace, and this has a large proportion of sulphur. The others are probably too poor in iron to be separately smelted with profit; but they might be mixed with richer ores with advantage. Other analyses of the so-called Black-band ores of this region are to be found in volume 1, Kentucky Geological Reports, pages 346 to 350. It will be seen, by reference, that these vary in their proportion of iron from 31.17 to 36.80 per cent. of the ore.

[No. 1314—"LIMESTONE *from Barren river, near the mouth of Jasper Creek. Used formerly as a flux at Airdrie Furnace.*" (*See Butler county.*)]

No. 1613—CLAY "*From Ross coal mines, Owensboro Junction. (Fire-clay below the coal in the lower drift.) Collected by C. J. Norwood.*"

A dark-grey, soft, shaly clay.

COMPOSITION, DRIED AT 212° F.

Silica	63.180	
Alumina, and iron and manganese oxides	26.281	
Lime	.203	
Magnesia	.255	
Phosphoric acid	.179	
Sulphuric acid	3.282	= 1.312 per cent. of sulphur.
Potash	2.000	
Soda	.425	
Water expelled at red heat, and loss	4.195	
	100.000	

Much of the sulphur and iron doubtless exist in the clay, not as sulphuric acid and iron oxide, but in combination, as iron sulphide. The considerable proportions of potash, lime, magnesia, and iron oxide may prevent this from being a *very* refractory clay; although it may very well answer for the manufacture of stone-ware and ordinary fire-bricks.

No. 1614—PIG IRON. (*Silver-grey.*) "*An old sample, from a former smelting at Airdrie Furnace. Collected by P. N. Moore.*"

No. 1615—PIG IRON. (*Silver-grey.*) "*From a former smelting, Airdrie Furnace, &c.*"

No. 1616—"PIG IRON (*silver-grey,*) *&c., &c., as above.*

No. 707—(See volume 3 Kentucky Geological Reports (old series), page 340, for an analysis of a somewhat similar pig iron from this furnace, made when the furnace was in blast.)

COMPOSITION OF THESE AIRDRIE FURNACE PIG IRONS.

	No. 1614.	No. 1615.	No. 1616.	*No. 707.
Specific gravity	6.826	6.826	7.782	7.007
Iron	86.636	85.455	86.842	88.426
Graphite	.900	.480	.740	1.360
Combined carbon	2.080	1.560	1.460	.190
Manganese	.202	.696	.355	.980
Silicon	7.704	7.747	8.614	6.216
Slag	2.260	3.460	2.360	3.090
Aluminum	.123	.098	.054	.099
Calcium	.045	.089	.112	not est.
Magnesium	.035	.017	.056	.309
Potassium	not est.	not est.	not est.	.059
Sodium	not est.	not est.	not est.	.091
Phosphorus	.235	.443	.123	.209
Sulphur	.104	.122	.122	219
Total	100.334	100.167	100.836	101.250
Total carbon	2.980	2.040	2.200	1.550

*Of old series of Reports.

The analyses of these samples of the pig iron of old Airdrie Furnace show inordinate proportions, in all of them, of silicon, slag, phosphorus, and sulphur; which caused the very bad quality of the iron, as they all tend to make it brittle, whether hot or cold. But the examination of the ores, limestone, and coals of the neighborhood of this furnace, shows that, with due care in the selection of these materials, and a proper management of the furnace, as good iron could be produced by it as by any using pit coal or coke for fuel.

It appears that, in its early working, the limestone used for flux was very sulphurous, containing much pyrites; that the manager had too strong a preference for the so-called "Blackband" over the limonite ores, which former frequently contain much sulphur and phosphorus; and that, moreover, the blast was too slow and too hot—conditions which all tended to the production of impure iron.

An account of the examination of some of the coke used formerly in this furnace is appended, as follows:

No. 1617 — COKE. *"Airdrie Furnace coke, weathered sixteen years; made from the No. 12 coal. Collected by P. N. Moore."*

COMPOSITION, AIR-DRIED.

Hygroscopic moisture (expelled at 212° F.)	7.50
Moisture, &c., expelled at red heat	4.20
Dry coke	88.30
Total	100.00
Total moisture and volatile matter	11.70
Fixed carbon	82.90
Ashes, of a light yellowish-grey color	5.40
Total	100.00
Per centage of sulphur	0.64

The ash of this coke was also analyzed.

COMPOSITION OF THE ASH.

	Per cent. of the coke.
Alumina, and iron and manganese oxides	0.40
Lime	.34
Magnesia	.18
Phosphoric acid	.08
Sand and insoluble silicates	4.32
Loss	.08
Total	5.40

The analysis of the coal of which this coke was made is given in the following (Nos. 1618 and 1619):

No. 1618—COAL. *"No. 12 of Owen. Airdrie Furnace, near No. 4 entry. Average sample, by P. N. Moore."*

A deep-black coal, with some thin shaly laminæ.

No. 1619—COAL. *"No. 12 of Owen. From the old stock pile, at the entrance of the drift; where it has been weathered for sixteen years. Average sample, by P. N. Moore."*

Like the preceding, but altered somewhat by weathering.

No. 1620—COAL. *"Average sample of the lowest division of the bed at Paradise mines. Airdrie Furnace. (No. 11 of Owen.) By P. N. Moore."*

A bright, deep-black coal; with but little fibrous coal between the layers, but containing small bright crystals and incrusting scales of iron pyrites.

No. 1621—COAL. *"Average sample of the middle stratum of same beds of Paradise mine. By P. N. Moore."*

A pure looking, deep-black coal, with shining fracture; showing less fibrous coal and iron bi-sulphide than the preceding.

No. 1622—COAL. *"Average sample of the upper stratum of Paradise mine, &c. By P. N. Moore."*

Like the two preceding; having a shining fracture, like that of asphaltum. Very little fibrous coal or pyrites to be seen in it.

No. 1623—COAL. *"From Muddy river coal mine. Averaged by P. N. Moore."*

A deep-black, glossy coal, with but little fibrous coal or pyrites apparent in it. Like the Paradise mine coal.

COMPOSITION OF THESE AIRDRIE FURNACE COALS, AIR-DRIED.

	No. 1618.	No. 1619.	No. 1620.	No. 1621.	No. 1622.	No. 1623.
Specific gravity	1.278	1.332	1.331	1.326	1.274	1.221
Hygroscopic moisture	3.60	4.70	4.20	4.10	3.60	3.80
Volatile combustible matters	31.40	30.60	36.10	35.90	38.70	32.70
Coke	65.00	64.70	59.70	60.00	57.70	63.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.00	35.30	40.30	40.00	42.30	36.50
Carbon in the coke	58.50	58.80	50.50	53.60	53.70	58.60
Ashes	6.50	5.90	9.20	6.40	4.00	4.90
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of coke	Dense spongy.	Dense spongy.	Spongy.	Spongy.	Spongy.	Dense spongy.
Color of ash	Lilac-grey.	Light lilac-grey	Dark lilac-grey	Dark lilac-grey	Light lilac-grey	Brownish. salmon-grey.
Per centage of sulphur	1.438	1.455	4.573	4.394	3.158	1.923

It appears that the No. 12 coal contains the least sulphur, while the No. 11 coal of the Paradise mine is quite sulphurous, the upper stratum being the least objectionable in this respect. They are all very good coals for ordinary uses, and might be measurably purified from sulphur by careful coking, and thus probably made available in the iron manufacture. The coal of the No. 12 bed of Owen is, however, preferable for this purpose.

No. 1624—COAL. "*Ross coal mine. Owensboro Junction. Top bench; above the clay parting. From the upper drift. Average sample, by C. J. Norwood.*" (*Coal A.*)

A jet-black coal, with fibrous coal between its thin laminæ, and but little apparent pyrites.

No. 1625—COAL. "*Mercer coal mines. Louisville and Paducah and Southwestern Railroad. Collected by C. J. Norwood.*" (*Coal D.*)

A jet-black coal, with shining pyrites, and some fibrous coal between the laminæ.

No. 1626—COAL. "*Upper seam of the old drift. Muhlenburg coal mines. Collected by C. J. Norwood.*" (*Coal A.*)

A glossy, pure-looking, pitch-black coal; with very little fibrous coal or pyrites apparent. Some little incrustation of lime sulphate in the seams.

No. 1627—COAL. "*Muhlenburg mines. Main working bed, near Mercer Station, Louisville and Paducah and Southwestern Railroad. Collected by C. J. Norwood.*" (*Coal B.*)

Like the next preceding, but has a little more fibrous coal than that, and some thin pyritous and lime sulphate incrustations.

No. 1628—COAL. "*Muhlenburg mines (John Pollock, Superintendent), near Mercer Station, &c., &c. Taken from head of main entry. Average sample, by C. J. Norwood.*"

A pure pitch-black looking coal; beautifully iridescent on some of the seam faces. But little fibrous coal or pyrites apparent, but some slight lime sulphate incrustation.

No. 1629—"FIBROUS COAL OR MINERAL CHARCOAL. "*From above the main working. Thickness from one half to one inch. Muhlenburg mines, &c. Collected by C. J. Norwood.*"

A very soft, friable mass of carbonaceous matter. Some in light powder, but much in the form of charred, fibrous, reedy stems, &c.

No. 1630—CARBONACEOUS MUD OR CLAY. "*Filling cavities occurring in the bituminous shale overlying the coal. Muhlenburg mines. Collected by C. J. Norwood.*"

A brownish greyish-black indurated mud, or carbonaceous clay.

COMPOSITION OF THESE MUHLENBURG COUNTY COALS, &c., AIR-DRIED.

	No. 1624	No. 1625	No. 1626	No. 1627	No. 1628	No. 1629	No. 1630
Specific gravity	1.407	1.358	1.297	1.332	1.280	1.503	. . . .
Hygroscopic moisture . .	4.16	3.60	3.10	1.52	2.98	1.20	3.56
Vol'ile combustible matters	37.44	34.00	40.68	40.00	43.08	7.50	13.68
Coke	58.40	62.40	56.22	58.48	53.94	91.30	82.76
Total	100.00	100.00	100.000	100.00	100.00	100.00	100.00
Total volatile matters . .	41.60	37.60	43.78	41.52	46.06	8.70	17.24
Carbon in the coke . . .	49.80	50.60	50.66	50.92	50.22	86.48	6.82
Ashes	8.60	11.80	5.56	7.56	3.72	4.82	75.94
Total	100.00	100.00	100.000	100.00	100.00	100.00	100.00
Character of the coke . .	Light spongy.	Light spongy.	Spongy.	Spongy.	Spongy.	Powdery.	Powdery.
Color of the ash	Light lilac-grey	Lilac-grey.	Lilac-grey.	Lilac-grey.	Lavendar grey.	Dark-brown.	Brownish grey.
Per cent. of sulphur . . .	2.727	4.032	2.779	2.840	3.125	3.431	1.983

These coals are generally of very good quality, although some of them contain a little more than the usual proportion of sulphur. Some of this, however, is in combination, in the form of *lime sulphate*. To ascertain how much was in this state, coals Nos. 1626 and 1629 were boiled in solution of soda carbonate, &c., &c., and the proportions of lime sulphate ascertained. The quantity in No. 1626 was only 0.168 per cent., while No. 1629 was found to contain 3.632 per cent. of this substance. In addition, No. 1629 was treated with bi-sulphide of carbon, by the method of displacement, and was thus found to contain a certain amount of uncombined sulphur. It is probable that in other coals free sulphur may be found, especially in those which have much fibrous coal between their laminæ.

The fibrous coal above described is remarkable for the large proportion of carbon it contains. The carbonaceous mud, on the contrary, contains but little combustible matter. It would be a bituminous shale if indurated.

OHIO COUNTY.

No. 1631—COAL. "*Rockport mines, one and three quarter miles east of Rockport. Average sample, from along the entry. Collected by C. J. Norwood.*" (*Coal D.*)

Rather friable. Pitch-black, with some incrustations of shining pyrites in the seams, and some fibrous coal between the laminæ.

No. 1632—COAL. "*Same locality, &c. Average sample, by C. J. Norwood.*" *General average of the mine.* (*Coal D.*)

A pitch-black coal, with fibrous coal between the layers; some infiltration of lime sulphate in the seams, and but little pyrites.

No. 1633—COAL. "*Same locality, &c. Averaged by C. J. Norwood.*" (*Coal D.*)

Much like the preceding.

COMPOSITION OF THESE OHIO COUNTY COALS, AIR-DRIED.

	No. 1631.	No. 1632.	No. 1633.
Specific gravity	1.421	1.332	1.334
Hygroscopic moisture	3.50	3.00	3.00
Volatile combustible matters	35.00	36.20	33.50
Coke	61.50	60.80	63.50
Total	100.00	100.00	100.00
Total volatile matters	38.50	39.20	36.50
Carbon in the coke	52.50	53.70	55.10
Ashes	9.00	7.10	8.40
Total	100.00	100.00	100.00
Character of the coke	Light spongy.	Light spongy.	Light spongy.
Color of the ash	Light brownish-grey.	Light lilac-grey.	Lilac-grey.
Per centage of sulphur	3.139	2.837	3.332

These coals are all of very good quality.

[See Appendix for other Ohio county coals.]

No. 1634—"VIRGIN SOIL *from woodland, on Mr. Miller's land, fifteen hundred and twenty feet north to east from Horse Branch Station (Louisville and Paducah Railroad). Collected by C. S. Schenk.*"

Slope 1:16. Depth of sample six inches. Substratum sandstone. Timber: white and black oak, some chestnut, hickory, and poplar. Undergrowth: sassafras, dogwood, and small trees of above named kinds. The new land is said to produce of corn, forty to fifty bushels; wheat, twenty to thirty; oats, forty to fifty; and of tobacco, one thousand pounds to the acre.

Dried soil of a dark brownish-grey color. No gravel.

No. 1635—"SUB-SOIL *of the preceding, taken at depth of from six to thirty-six inches. By C. S. Schenk.*"

Sub-soil of a light grey-buff color. No gravel.

No. 1636—"SOIL *of an old field, forty years in cultivation. Level table land, owned by Mr. Miller, sixteen hundred feet north 20° east, from Horse Branch Station, &c. Collected by C. S. Schenk.*"

Sample taken to the depth of seven and a half inches. Substratum sandstone. Rotation of crops: tobacco two years, corn three years (in some cases corn until it fails to produce it), then wheat and clover, or oats and clover or grass. Yield of corn, twenty to thirty bushels; oats, twenty to thirty-five bushels; tobacco, six hundred pounds per acre. Never plowed over six or seven inches deep. Good quality of table-land; nearly as good as the valley land.

Dried soil of a greyish light-brown color. Contains a few small fragments of ferruginous sandstone.

No. 1637—"SUB-SOIL *of the next preceding, taken to the depth of from seven and a half to thirty-six inches. Collected by C. S. Schenk.*"

Dried sub-soil of a yellowish-grey color. Contains no gravel.

COMPOSITION OF THESE OHIO COUNTY SOILS, DRIED AT 212° F.

	No. 1634.	No. 1635.	No. 1636.	No. 1637.
Organic and volatile matters	4.100	3.500	3.550	3.350
Alumina, and iron and manganese oxides	3.032	7.047	4.066	6.475
Lime carbonate	.170	.095	.095	.095
Magnesia	.131	.258	.104	.171
Phosphoric acid	.093	.093	.124	.140
Sulphuric acid	Not estimated.			
Potash	.125	.273	.333	.269
Soda	a trace.	.144	.012	.230
Sand and insoluble silicates	92.455	88.841	91.990	89.515
Water expelled at 380° F.	.900	.915	.775	.775
Total	101.066	101.165	101.049	101.020
Hygroscopic moisture	1.175	2.400	1.450	2.575
Potash in the insoluble silicates	1.273	1.470	.939	1.107
Soda in the insoluble silicates	.814	.617	.511	.290
Character of the soil	Virgin soil.	Sub-soil.	Old field soil.	Sub-soil.

The old field soil seems to have been naturally richer than the woodland soil, if no mistake has been made in the labels. The considerable proportions of potash and soda in the sandy portion (insoluble silicates) tend to give durability to the soils. With proper culture and the due application of fertilizers, this land may be made quite productive, if well drained

For the analyses of other soils of this serial collection, made by Mr. C. S. Schenk along the line of the Elizabethtown and Paducah Railroad, see Grayson and Hardin counties.

APPENDIX.

BOURBON COUNTY.

No. 1638—"LIMESTONE (*magnesian*). *From Cane Ridge; five miles east of Paris. Used for the foundation of the Bourbon county Court-house at Paris. Sent by Mr. James Stevenson.*"

A somewhat porous, fossiliferous, ferruginous, magnesian limestone, of a light grey-buff color, containing small specks of hydrated oxide of iron. Specific gravity = 2.58 to 2.60 (in the lump).

COMPOSITION, DRIED AT 212° F.

Lime carbonate	79.140 = 44.318 per cent. of lime.	
Magnesia carbonate	11.826 = 5.371 per cent. of magnesia.	
Alumina	.380	
Iron peroxide	5.510	
Phosphoric acid	.511	
Sulphuric acid	.240	
Potash	.231	
Soda	.252	
Soluble silica	.110	
Insoluble silica	1.160	
Loss	.640	
	100.000	

The magnesian limestones are believed to withstand the atmospheric agencies generally better than the pure limestones. The iron in this rock is all in the state of peroxide, which is also favorable to its durability.

Whether its small cavities or pores may retain enough water to cause disintegration by freezing was not ascertained. It would calcine into lime good for ordinary building purposes or for use on the soil as a fertilizer.

COALS FROM THE STATE OF OHIO.

For the purpose of comparing our Kentucky coals with some of the best of those of our neighboring States, some of these, collected by Messrs. P. N. Moore and A. R. Crandall, were submitted to analysis, as follow:

No. A. 1—"COAL *from Jackson county, Ohio. Star Furnace coal. Averaged by A. R. Crandall.*"

A glossy, jet-black splint coal; breaking into thin laminæ, with fibrous coal between.

No. A. 2—"COAL. *Hocking valley, Athens county, Ohio. Average sample from the whole thickness of the bed. Taken from the pillar, three hundred yards. By A. R. Crandall.*"

A pitch-black, glossy coal, iridescent on some of the faces; having very little fibrous coal, and no pyrites apparent.

No. A. 3—"COAL. *Hocking valley, &c., &c. Average sample from the stock pile, from the whole thickness of the bed. By A. R. Crandall.*"

Like the preceding, but brighter, and showing less fibrous coal.

No. A. 4—COAL. *Hocking valley, &c., &c. Average sample from the upper twenty-eight inches. Taken from two rooms. By A. R. Crandall.*"

Breaks into thinner laminæ than the two preceding, with more fibrous coal between. Some little shining pyrites in thin crusts.

No. A. 5—"COAL. *Hocking valley, &c., &c. Average sample from the middle part (twenty-six inches), taken from two rooms. By A. R. Crandall.*"

In thicker laminæ than preceding, with much less fibrous coal, and no appearance of pyrites between them. Handsomely iridescent on many of the seam faces.

No. A. 6—"COAL. *Hocking valley, &c., &c. Average sample, from the lower part (eighteen inches) of the bed. Taken from two rooms. By A. R. Crandall.*"

Resembles the preceding, but shows some bright pyrites in places.

No. A. 12 — "COAL. *Sheridan coal mines, Lawrence county, Ohio. Collected by P. N. Moore.*"

A pure, pitch-black coal; with very little fibrous coal and some fine-granular pyrites, between the laminæ.

COMPOSITION OF THESE SELECTED OHIO COALS, AIR-DRIED.

	A. 1.	A. 2.	A. 3.	A. 4.	A. 5.	A. 6.	A. 12.
Specific gravity	1.361	1.322	not det'd.	1.346	1.303	1.312	1.322
Hygroscopic moisture . .	4.54	3.60	4.20	3.26	3.74	4.40	3.46
Vol'ile combustible matters	29.68	33.42	36.68	33.76	36.32	35.08	36.64
Coke	65.78	62.98	59.12	62.98	59.94	60.52	59.90
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters . .	34.22	37.02	40.88	37.02	40.06	39.48	40.10
Carbon in the coke . . .	57.06	55.82	54.16	54.42	55.74	55.20	53.80
Ashes	8.72	7.16	4.96	8.56	4.20	5.32	6.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke . .	Pulverulent.	Dense.	Spongy.	Dense.	Dense spongy.	Dense spongy.	Light spongy.
Color of the ash	Nearly white.	Brownish grey.	Light lilac-grey	Light lilac-grey	Light lilac-grey	Light lilac-grey	Light lilac-grey
Per centage of sulphur. .	0.756	0.862	1.692	2.247	1.299	1.659	1.947

These are remarkably good coals, and are acknowledged to be amongst the best of the country.

The sample A. 2, taken from the pillar, seems to show the effect of exposure to the atmosphere, which is generally believed to cause a diminution of the proportion of sulphur.

A correspondence may be observed between the proportion of *ash* and the specific gravity, as follows:

A. 5	has	specific	gravity =	1.303,	and ash per cent. =	4.20
A. 6	has	"	"	1.312,	" "	5.32
A. 2 and A. 13	have	"	"	1.322,	" "	6.10 and 7.16
A. 4	has	"	"	1.346,	" "	8.50
A. 1	has	"	"	1.361,	" "	8.72

COALS FROM THE STATE OF ILLINOIS.

No. A. 7—COAL. "*Mine near Murphrysboro, Jackson county, Illinois. Block coal. Big Muddy coal. Average sample, by P. N. Moore.*"

A glossy, jet-black splint coal. It has some fibrous coal between the laminæ; with occasional scales of bright pyrites, and some slight lime sulphate incrustation in the seams.

No. A. 8—"COAL. *Big Muddy coal. Mine near Murphrysboro, Illinois. Average sample, by P. N. Moore.*"

Like the preceding. Some fine-granular pyrites with the fibrous coal between the laminæ, and occasional lime sulphate incrustation in the seams.

COMPOSITION OF THESE ILLINOIS COALS, AIR-DRIED.

	No. A. 7.	No. A. 8.
Specific gravity	1.310	1.310
Hygroscopic moisture	2.62	3.44
Volatile combustible matters	32.04	31.86
Coke	65.34	64.70
Total	100.00	100.00
Total volatile matters	34.66	35.30
Carbon in the coke	58.58	59.54
Ashes	6.76	5.16
Total	100.00	100.00
Character of the coke	Light spongy.	Spongy.
Color of the ash	Lilac-grey.	Lilac-grey.
Per centage of sulphur	2.472	1.376

These are also remarkably good coals, containing only a moderate proportion of sulphur, which is partly in the form of iron sulphide and partly in that of lime sulphate.

COALS FROM THE STATE OF INDIANA.

No. A. 9—"INDIANA BLOCK COAL. *From near Brazil, Clay county. Upper seam. Average sample, by P. N. Moore.*"

A pitch-black splint coal, breaking easily into thin laminæ, with fibrous coal (mineral charcoal) and some fine granular

pyrites between them. A few bright scales of iron pyrites and some slight lime sulphate incrustation in the seams.

No. A. 10—"INDIANA BLOCK COAL. *Mine near Brazil, Clay county. Lower seam. Average sample, by P. N. Moore.*"

Like preceding, but little appearance of pyrites or lime sulphate.

No. A. 11—"INDIANA BLOCK COAL. *From mine near Brazil, &c. Lower seam. Average sample, by P. N. Moore.*"

Resembles the others. Shows occasional bright scales of pyrites and lime sulphate incrustation.

COMPOSITION OF THESE INDIANA COALS, AIR-DRIED.

	No. A. 9.	No. A. 10.	No. A. 11.	No. A. 11 (repeated).
Specific gravity	1.313	not est.	not est.	. . . . .
Hygroscopic moisture	2.70	2.68	2.40	2.52
Volatile combustible matters	36.38	36.32	35.10	35.48
Coke	60.92	61.00	62.50	62.00
Total	100.00	100.00	100.00	100.00
Total volatile matters	39.08	39.00	37.50	38.00
Carbon in the coke	55.64	53.58	53.50	53.06
Ashes	5.28	7.42	9.00	8.94
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Dense spongy.	Dense.	. . . . .
Color of the ash	Lilac-grey.	Light lilac-grey.	Lilac-grey.	. . . . .
Per centage of sulphur	1.664	1.802	2.373	. . . . .

These are remarkably good coals, as is well known by experience, especially in their use in the smelting of iron. Their high reputation and successful application to this industry make the comparison of their composition, with that of our Kentucky coal, an object of interest; and as we could find in

the excellent reports of the Chief Geologist of Indiana, Prof. E. T. Cox, no statement as to the amount of *sulphur* which they contain, an ingredient of great and evil influence in iron smelting, these block coals were examined especially for this determination.

It will be seen on reference to the preceding table that this ingredient exists in them in average proportion. Doubtless to the existence of the sulphur in this fuel may we attribute the fact, given by Prof. Cox, on page 70 of his First Annual Report, 1869, that "the general character of the iron made in Clay county is *red-short*, &c." This, however, may be measurably corrected, and indeed does not prevent the iron from being very good and profitable for many industrial purposes.

It is very probable that all the sulphur which exists in these coals in the free, or uncombined, condition, will be volatilized and burnt out at the upper part of the furnace, long before it encounters the heat necessary to cause its combination with the iron of the ore with which it is mixed. This would be the case also with the second atom of sulphur of the bright pyrites of the coal, the bi-sulphide of iron; so that only that portion of the sulphur which would remain in the resulting iron proto-sulphide could vitiate the cast iron product. Hence we can understand, how a coal which gives a considerable per centage of sulphur in its ultimate analysis, may yet be quite available for the smelting of tough iron.

CALIFORNIA ADOBÉ SOIL.

An opportunity having occurred for procuring a specimen of this remarkably fertile soil, it was analyzed for comparison with our Kentucky soils, with the following results.

No. A. 12—"ADOBÉ SOIL *taken at three inches below the surface. Valley of the Sacramento river. Solano county, California." Collected by Robert Peter, jr.*

Dried soil of a light-umber color; adhering in clods, which are easily crushed in the mortar. The powder (unground) passed wholly through fine bolting-cloth, leaving only a few vegetable fragments.

COMPOSITION OF THE AIR-DRIED SOIL.

	No. A. 12.	No. 1329.
Organic and volatile matters	7.740	7.615
Alumina, and iron and manganese oxides	11.117	12.085
Lime carbonate	.790	.990
Magnesia	1.596	.520
Phosphoric acid	.093	.483
Sulphuric acid	.082	a trace.
Potash	.727	.726
Soda	.983	a trace.
Sand and insoluble silicates	74.070	75.590
Water and loss	2.802	1.891
Total	100.00	100.000
Potash in the insoluble silicates	0.814	2.731
Soda in the insoluble silicates	0.903	.929

It will be seen above that this adobé soil resembles in composition the peculiar rich soil found locally in Campbell county, Kentucky, No. 1329, which is also like the adobé in being a sticky clay when wet, and hard and cloddy when dry. The California soil exceeds our Kentucky soils in soda, the latter has more phosphoric acid.

LYON COUNTY.—(Continued.)

No. 1639—"*Water taken from the interior of a geode of iron ore—pot iron ore. Suwannee, Lyon county. Summit Cut ore bank. Sent by A. L. Anderson, Esq.*"

The water had a strong astringent taste; and had deposited much ferruginous sediment in the bottle. It was analyzed by my youngest son, Alfred M. Peter, in my laboratory.

COMPOSITION IN 100 PARTS OF THE WATER, APART FROM THE SEDIMENT.

Iron protosulphate	0.2435
Alumina sulphate	.4981
Manganese sulphate	.1004
Lime sulphate	.1209
Magnesia sulphate	.0609
Potash sulphate	.0257
Soda sulphate	.0651
Sodium chloride	.0053
Phosphoric acid	.0028
Total	1.1227

The analyses of some other samples of water, from the pot ore of Trigg county, are given in volume 4, page 260–1, of Kentucky Geological Reports.

EDMONSON COUNTY.—(Continued.)

No. 1640—LIMONITE. "*Old Nolin Furnace bank, near the furnace ore. Bank about a quarter of a mile north of the furnace. Davis' branch of Nolin river. Average sample, by P. N. Moore.*"

Generally of a brownish-red color. A porous ore, with some whitish portions.

COMPOSITION, DRIED AT 212° F.

Iron peroxide	27.340	= 19.138 per cent. of iron.
Alumina	5.930	
Manganese oxide	not det'd.	
Lime carbonate	1.090	
Magnesia	.447	
Phosphoric acid	1.068	= .497 per cent. of phosphorus.
Sulphuric acid	not det'd.	
Water expelled at red heat	12.380	
Silica and insoluble silicates	51.230	
Manganese oxide, alkalies, sulphuric acid, &c.	.515	
	100.000	

This ore is too poor in iron to be valuable. It is probable that its phosphorus is somewhat over-estimated.

No. 1643—PIG IRON. "*From old Nolin Furnace. Cold blast.*" *Furnace long since out of blast.*

A fine-grained grey iron, which yields easily to the file, and extends considerably under the hammer. Seems to be tougher than usual cast iron.

COMPOSITION.—SPECIFIC GRAVITY = 7.113.

Iron	94.287	
Graphite	3.100	= 3.800 total carbon.
Combined carbon	.700	
Silicon	.493	including that in the slag.
Phosphorus	1.029	
Sulphur	.012	
Undetermined ingredients and loss	.379	
	100.000	

This appears to be a remarkable instance of cast iron remaining tough although it contains a considerable proportion of phosphorus, which is believed to render it "cold-short," or

brittle at the ordinary temperature, in quantities even less than one per cent. Possibly the quite small per centage of silicon, which also renders iron brittle, may have something to do with this apparent anomaly.

The phosphorus in the above analysis was first determined as phosphate of bismuth, by the process of Chancel; but not satisfied with this determination, this phosphate, after solution in chlorohydric acid, was decomposed by sulphydric acid, and the separated phosphoric acid re-determined by means of the magnesia mixture, in the usual way; and this without any material alteration in the result obtained.

GRAYSON COUNTY.—(Continued.)

No. 1641 — "LIMONITE. "*Nolin Furnace ore bank, on the Brownsville road. Average sample, by P. N. Moore.*"

In irregular layers, varying in color and density.

No. 1642—LIMONITE. "*From Meredith Ray's farm, Taylor's Fork of Bear Creek, opposite the Chalybeate Spring. Average sample, by P. N. Moore.*"

A pretty dense ore, generally of a dark-brown color, with some lighter colored portions.

COMPOSITION OF THESE GRAYSON COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1641.	No. 1642.
Iron peroxide	57.830	44.528
Alumina	6.719	1.368
Manganese oxide	Not determined.	
Lime carbonate	.290	5.590
Magnesia	.122	.609
Phosphoric acid	.921	1.074
Sulphuric acid	not deter'd.	.151
Water expelled at red heat	12.180	8.940
Silica and insoluble silicates	21.040	37.380
Undetermined and loss	.898	.360
Total	100.000	100.000
Iron, per centage	40.481	31.169
Phosphorus, per centage	.412	.468
Sulphur, per centage	not deter'd.	.060
Silica, per centage	14.360	not deter'd.

It is probable the phosphorus is somewhat over-estimated in these ores.

No. 1644 — CLAY IRON-STONE. *"The glady ore, on the old Brownsville and Litchfield road, west of Bear Creek, Grayson county."*

A dark-grey, fine-granular clay iron-stone, with much investing limonite ore.

COMPOSITION, DRIED AT 212° F.

Iron carbonate	16.598	= 37.945 per cent. of iron.
Iron peroxide	42.761	
Alumina	4.994	
Lime carbonate	2.840	
Magnesia carbonate	not det'd.	
Phosphoric acid	1.017	= .444 per cent. of phosphorus.
Sulphuric acid	a trace.	
Silica and insoluble silicates	20.830	
Water and loss	8.054	
	100.000	

BOYD COUNTY.—(Continued.)

No. 1645—COAL. No. 7. *Used at Ashland Furnace.*

A bright pure-looking coal, having but little fibrous coal between its laminæ; has some little bright pyrites and thin scales of lime sulphate in the seams.

COMPOSITION, AIR-DRIED.—SPECIFIC GRAVITY = 1.291.

Hygroscopic moisture	4.80	Total volatile matters	= 39.00
Volatile combustible matters	34.20		
Spongy coke	61.00	Carbon in the coke	= 54.90
		Light brownish-grey ash	= 6.10
	100.00		100.00

Per centage of sulphur = 1.312.

A very good and pure coal, which favorably compares with the best so-called "Block coal" of Indiana, and is well adapted to the purpose for which it is used.

CARTER COUNTY.—(Continued.)

No. 1646—COAL. No. 1. *"From Graham bank. Little Fork of Little Sandy river. Collected by P. N. Moore."*

A pure-looking coal, which has some fibrous coal between its laminæ; but shows very little pyrites.

No. 1647—COAL. No. 1. *"From Graham bank, &c. Sample from all parts of the mine."*

COMPOSITION OF THESE CARTER COUNTY COALS, AIR-DRIED.

	No. 1646.	No. 1647.
Specific gravity	1.269	not deter'd.
Hygroscopic moisture	3.50	3.60
Volatile combustible matters	36.30	35.40
Coke	60.20	61.00
Total	100.00	100.00
Total volatile matters	39.80	39.00
Fixed carbon in the coke	57.30	57.60
Ashes	2.90	3.40
Total	100.00	100.00
Character of the coke	Spongy.	Spongy.
Color of the ash	Brownish-grey.	Brownish-grey.
Per centage of sulphur	1.148	1.107

Remarkably good and pure coals.

GREENUP COUNTY.—(Continued.)

No. 1648—COAL. No. 1. "*Raccoon Creek. Raccoon Furnace. Collected by P. N. Moore.*"

A splint coal, with quite thin laminæ and considerable fibrous coal between. Some little iron stain, but little appearance of pyrites.

No. 1649—COAL. "*Hunnewell cannel coal. Hunnewell mines.*"

	No. 1648.	No. 1649.
Specific gravity	1.409	1.306
Hygroscopic moisture	4.10	1.50
Volatile combustible matters	28.90	52.20
Coke	67.00	46.30
Total	100.00	100.00
Total volatile matters	33.00	53.70
Fixed carbon in the coke	49.60	40.60
Ashes	17.40	5.70
Total	100.00	100.00
Character of the coke	Pulverulent	Very friable
Color of the ash	Light-grey, nearly white	Light yellowish-grey.
Per centage of sulphur	0.655	0.782

This cannel coal is remarkably pure and good. Its proportion of volatile combustible matters (52.20 per cent.) is remarkably great.

OHIO COUNTY.—(Continued.)

No. 1650—COAL (D.) "*From Taylor coal mines, near Beaver Dam, Ohio county. Collected by C. J. Norwood. (Rather better than a fair average.*")

A bright-looking coal, with but little fibrous coal between the laminæ, but with some scales of bright pyrites.

No. 1651—COAL (D.) "*Stevens' coal mine, near Beaver Dam, &c. Collected by C. J. Norwood.*"

Has more fibrous coal than the preceding, but shows less pyrites. Iridescent in parts.

COMPOSITION, AIR-DRIED.

	No. 1650.	No. 1651.
Specific gravity	1.315	1.316
Hygroscopic moisture	3.30	3.30
Volatile combustible matters	35.84	36.76
Coke	60.86	59.94
Total	100.00	100.00
Total volatile matters	39.14	40.06
Fixed carbon in the coke	54.36	52.60
Ashes	6.50	7.34
Total	100.00	100.00
Character of the coke	Spongy.	Spongy.
Color of the ash	Chocolate-grey.	Brownish-grey.
Per centage of sulphur	3.874	2.608

These are both very good coals; ranking amongst the best.

TABLE I. SOILS, SUB-SOILS, &c., DRIED AT 212° F.

Number in Report.	County.	Organic and volatile matters.	Alumina	Iron oxide.	Manganese oxide.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Water lost at 380°.	Hygroscopic moisture.	Potash in the silicates.	Soda in the silicates.	Extracted from 1000 parts by carbonic acid water.	Remarks.
1298	Boyd	3.140		5.091		0.214	0.034	0.134	a trace	0.317	0.076	90.430	0.650	1.375	not est	not est	not est.	Virgin soil (valley).
1299	Boyd	3.085		6.642		.116	.178	.068	a trace	.317	.093	88.420	.525	1.735	not est	not es.	not est	Sub-soil of same.
1300	Boyd	7 985		7.425		.571	.302	.208	a trace	.435	.045	81.410	.915	2.225	not est	not est	not est	Virgin soil (slope of hill).
1301	Boyd	5.190		9 984		.392	.251	.191	a trace	.225	.050	83.233	.550	1.700	not est	not est	not est	Sub-soil of same.
1302	Boyd	4.915		9.049		.252	.333	.156	0.048	.344	.023	83.705	1.235	2.335	not es.	not est	not est.	Old field soil.
1303	Boyd	4.905		9.075		.270	.053	.164	a trace	.282	.170	83 385	1.315	2.840	not est	not est	not est.	Sub-soil of same.
1304	Bracken	4.140	5.837	7.154	.225	a trace.	.297	.233	a trace	.110	a trace	82.140	1.015	2.200	not est	not est	1.316	Old field.
1305	Bracken	4.775	5.513	6.625	.17	a trace	.289	.424	a trace	.197	.174	81.97	1.100	3.200	not est	not est	0.960	Sub-soil.
1306	Bracken	3.335	3.837	3.965	.070	a trace	.205	.217	a trace	.135	.076	87.815	not est	2.300	not est	not est	0.660	Old field, worn spot.
1324	Campbell	3.650	3.375	3.125	.059	.130	.034	.145	a trace	.120	.047	87.545	1.160	1.765	not est	not est	2.322	Virgin soil.
1325	Campbell	2.555	3.415	3.038	.037	.091	.496	.109	a trace	.062	.132	89 335	1.110	1.555	1.311	0.750	1.870	Old field soil.
1326	Campbell	2.540	3.900	3.474	not est	.145	.058	.091	a trace	.064	.160	88.375	1.020	1.690	not est	not est	1.220	Old field soil.
1327	Campbell	2.435	3.868	3.972	.427	.125	.250	.121	a trace	.062	.109	87.500	1.040	2.235	1.477	.339	0.890	Sub-soil.
1328	Campbell	8.965	4.040	4.787	.471	.450	.250	.063	a trace	.241	.071	78.963	1.550	2.550	not est	not est	1.860	New soil.
1329	Campbell	7.015	5.175	6 750	.200	.990	.520	.450	a trace	.726	a trace	75 59	1.85	5 075	2.731	.929	2.700	Virgin soil (Youtsey's)
1330	Campbell	5.960	5.323	6.890	.068	3.800	.500	.315	a trace	.593	.019	75.415	1.017	4.330	not est	not est	5.650	Sub-soil (Youtsey's).
1331	Campbell	5.160	3.185	4.380	.390	a trace	0.474	.420	a trace	0.443	.045	83.775	1.25	4.825	not est	not est	0.720	Gravelly loam.
1332	Campbell	2.775	1.587	2.980	.07	a trace	.191	.250	a trace	.115	.048	91.635	1.035	1.400	not est	not est	1.080	Old field soil.
1333	Campbell	2.135	2.737	4.465	.320	a trace	.305	.240	a trace	.125	.100	89.040	1.010	2.215	not est	not est	1.272	Old field soil.
1395	Carter	3.110		7.405		.420	.272	.06	a trace	.293	.148	87.630	.885	2.020	0 584	0.165	1.600	Virgin soil, near Olive Hill.
1396	Carter	4.800		17.360		.272	.124	.043	a trace	.062	.149	74.840	1.400	2.354	not est	not est	.770	Sub-soil, near Olive Hill.
1397	Carter	2.250		4.777		.850	.057	.093	a trace	.213	.132	91 690	.600	1.125	not est	not est	1.660	Old field, near Olive Hill.
1398	Carter	1.815		6.409		.092	.155	.097	a trace	.155	.151	90.515	.480	1.270	not est	not est	1.020	Sub-soil, near Olive Hill.
1399	Carter	4.163		7.595		.320	.088	.160	a trace	.275	.180	85.463	1.160	1.945	not est	not est	not est.	Virgin soil, near Iron Hill (woods).
1400	Carter	2.20		8.400		.155	.142	.149	a trace	.385	.169	87.340	.625	1.400	not est	not est	.820	Sub-soil, near Iron Hill.
1401	Carter	3.925		6.637		.160	.051	.116	a trace	.271	.103	88.140	.900	1.475	not est	not est	2.870	Old field, near Iron Hill.
1402	Carter	2.315		8.375		.095	.153	.111	trace	.273	.079	87.740	.555	1.405	not est	not est	.570	Sub-soil, near Iron Hill.
1403	Carter	4.685		4 013		.109	.05	.147	0.00	.153	.032	89 515	.995	1.380	not est	not est	not est	Virgin soil (woods), W. Br. Tygert's Cr'k.
1404	Carter	2.62		5.410		.169	.061	.163	.041	.371	.046	89 940	.770	1 270	not est	not est	not est	Sub-soil woods), W. Br. Tygert's Creek.
1405	Carter	2.860		4.540		.145	.035	.125	a trace	.111	.157	91.240	.690	1.215	not est	not est	1.18.	Old field, West Branch of Tygert's Creek.
1406	Carter	2.000		5.890		.080	.05	.160	a trace	.204	.131	91.575	.450	1.275	not est	not est	.540	Sub-soil, West Branch of Tygert's Creek.
1407	Carter	3.740		6.115		.245	.115	.070	a trace	.279	.280	89.390	.828	1.350	not est	not est	2.070	Old field, West Branch of Tygert's Creek.
1408	Carter	2.20		5.600		.220	.178	.080	a trace	.360	.587	91.215	.450	1.035	not est	not est	not est.	Sub soil, West Branch of Tygert's Creek.
1409	Carter	2.540		11.500		.560	.121	.223	a trace	. . .	. . .	84.000	not est	. . .	0.366	*0.587	not est.	Sub-soil (Grayson).
1424	Fayette	6.340		8.890		.745	.360	.55	.00	.169	.057	81.467	1.550	. . .	.905	.844	not est	Cultivated field (not old).
1425	Fayette	6.57		8.220		.430	.221	.310	.00	.247	.263	83.340	. . .	. . .	1.256	.362	not est.	Old field.
1437	Fulton	2.200		6.005		.239	0.411	0.172	no e	0.159	.072	90 490	.650	2.500	1.479	1.306	not est.	Sub-soil, old tobacco field.
1469	Grayson	3.850		7.215		.345	.240	.070	no est	.243	.125	86.850	.925	2.025	1.039	.479	not est.	Old field (on sandstone).
1470	Grayson	3.375		10.930		.105	.159	.160	not est	.308	.104	84.490	.425	2.925	. . .	. . .	not est	Old field sub-soil (on sandstone).
1471	Grayson	4.850		5.515		.145	.140	.125	not est.	.112	.051	88.790	1.325	2.125	1.022	.377	not est.	Virgin soil (on sandstone).

TABLE I. SOILS, SUB-SOILS, &c.—(Continued.)

Number in Report.	County.	Organic and volatile matters.	Alumina.	Iron oxide.	Manganese oxide.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Water lost at 380°.	Hygroscopic moisture.	Potash in the silicates.	Soda in the silicates.	Extracted from 1000 parts by carbonic acid water.	Remarks.
1472	Grayson. . . .	3.200		7.497		.045	.140	.093	not est	.105	.044	87.565	.875	2.700	. . .	. . .	. . . . .	Virgin soil sub-soil (on sandstone).
1473	Grayson. . . .	4.950		6.195		.340	.176	.125	not est	.327	.023	86.780	1.075	1.950	. . .	. . .	. . . . .	Virgin soil (on limestone).
1474	Grayson. . . .	3.350		6.647		.020	.104	.093	not est	.105	.070	88.965	1.100	1.651	. . .	. . .	. . . . .	Virgin soil sub-soil (on limestone).
1475	Grayson. . . .	4.170		4.172		.220	.167	.118	not est	.120	.045	90.640	1.100	1.775	. . .	. . .	. . . . .	Old field (on limestone).
1476	Grayson. . . .	3.275		6.022		145	.125	.093	not est	.405	. . .	89.580	.350	3.500	.828	.624	. . . . .	Old field sub-soil on limestone).
1537	Greenup . . .	5.050		6.831		a trace	.116	.089	0.058	.217	.055	86.505	1.000	1.650	not est	not est	. . . . .	New soil (coaled land), Pea Ridge.
1538	Greenup . . .	4.030		9.595		.123	.223	.115	.017	.231	.097	84.565	.685	1.775	not est	not est	. . . . .	Sub-soil of same.
1539	Greenup . . .	5.105		9.223		.091	.034	.192	.019	.312	.120	84.695	.615	2.150	not est	not est	. . . . .	Under clay of same.
1540	Hardin	3.675		5.790		.160	.250	.160	. . .	.154	.109	88.59	1.235	1.510	0.803	0.467	. . . . .	Old field (on limestone).
1541	Hardin	2.600		8.617		.195	.431	.123	. . .	.188	.002	86.975	.925	1.575	not est	not est	. . . . .	Sub-soil of same (on limestone).
1542	Hardin	2.650		10.775		.110	.158	.115	. . .	.265	.030	84.740	.750	2.140	not est	not est	. . . . .	Under clay of same (on limestone).
1543	Hardin	2.950		5.786		.195	.375	.119	. . .	.404	.030	89.555	.900	1.125	.617	.188	. . . . .	Virgin soil (on limestone).
1544	Hardin	2.500		9.705		.145	.240	.125	. . .	.462	.035	85.925	.850	1.650	.798	.400	. . . . .	Sub-soil of same (on limestone).
1545	Hardin	3.100		6.905		.245	.258	.204	. . .	.308	.033	87.465	1.100	1.325	.977	.280	. . . . .	Old field (on limestone).
1546	Hardin	2.025		9.190		.195	.140	.125	. . .	.327	.037	86.840	.725	1.700	not est	not est	. . . . .	Sub-soil of same (on limestone).
1547	Hardin	3.300		7.705		.295	.339	.156	. . .	.193	.027	86.815	1.050	1.500	not est	not est	. . . . .	Virgin soil (on limestone).
1548	Hardin	3 035		11.625		.110	.267	.216	. . .	.256	.160	83.925	.600	1.800	not est	not est	. . . . .	Sub soil of same (on limestone).
1549	Hardin	4.150		6.865		.495	.521	.108	a trace	.209	.079	86.590	1.250	1.650	not est	not est	. . . . .	New soil (on limestone).
1550	Hardin	2.750		8.870		.245	.284	.134	a trace	.399	.054	86.640	.850	1.875	not est	not est	. . . . .	Sub-soil of same (on limestone).
1551	Hardin	3.535		8.784		.230	.152	.156	a trace	.159	.026	86.215	.800	1.650	0.864	0.444	. . . . .	Old field.
1552	Hardin	3.150		11.900		.175	.321	.108	a trace	.150	.140	83 315	.700	2.200	not est	not est	. . . . .	Sub-soil of same.
1553	Hardin	1.950		5.926		.130	.167	.076	a trace	.163	.005	90.465	.935	1.585	1.140	0.641	. . . . .	Virgin soil.
1554	Hardin	1.990		8 344		.080	.204	.093	a trace	.298	.120	88.115	.775	2.200	not est	not est	. . . . .	Sub-soil of same.
1555	Hardin	2.185		5.692		.270	.213	.070	a trace	.250	.037	89.965	1.425	1.400	not est	not est	. . . . .	New soil.
1556	Hardin	2.135		9.476		.220	.208	.134	a trace	.313	.045	86.240	.900	2.400	not est	not est	. . . . .	Sub-soil of same.
1557	Hardin	2.100		6.359		.220	.050	.093	a trace	.223	.023	89.790	.950	1.485	0.562	0.373	. . . . .	Old field (on limestone).
1558	Hardin	2.935		12.798		.220	.194	.124	a trace	.342	.033	82.165	.975	2.650	not est	not est	. . . . .	Sub-soil of same (on limestone).
1559	Hardin	2.625		7.388		.190	.095	.124	a trace	.221	.026	88.090	1.150	1.385	.675	.339	. . . . .	Old field (on limestone).
1560	Hardin	2.525		10.445		.120	.362	.120	a trace	.339	.260	85.140	.950	2.450	not est	not est	. . . . .	Sub-soil of same (on limestone).
1561	Hardin	3.215		6.790		.370	.189	.172	a trace	.202	.049	87.765	1.400	1.600	1.148	.731	. . . . .	Old field (on limestone).
1562	Hardin	3.785		15.763		.620	.095	.124	a trace	.421	101	77.375	1.515	3.860	.974	.420	. . . . .	Sub-soil of same (on limestone).
1563	Hardin	3.080		6.564		.445	.213	.123	a trace	.293	.050	87.975	1.235	1.300	not est	not est	. . . . .	Old field (on limestone).
1564	Hardin	2.785		10.763		.495	.282	.124	a trace	.212	.219	84.290	1.135	1.375	not est	not est	. . . . .	Sub-soil of same (on limestone).
1565	Hardin	3.215		5.365		.445	.168	.172	a trace	.188	.041	87.940	1.525	1.890	1.550	.350	. . . . .	Virgin soil (on limestone).
1566	Hardin	4.400		6.395		.270	.205	.045	a trace	.202	.050	88.425	.650	1.800	. . .	. . .	. . . . .	Sub-soil of same (on limestone).
1567	Hardin	3.050		5.550		.305	.249	.102	a trace	.173	a trace	89.290	1.100	1.690	. . .	. . .	. . . . .	Old field (on limestone).
1568	Hardin	2.575		5.828		.236	.078	.112	a trace	.183	.053	90.470	.475	2.360	. . .	. . .	. . . . .	Sub-soil of same (on limestone).
1569	Hardin	2.600		4.465		.170	.176	.147	a trace	.212	.055	91.790	.775	1.225	1.332	.444	. . . . .	Virgin soil (on limestone).
1570	Hardin	2.225		7.015		.080	.104	.134	a trace	.202	.076	89.855	.450	1.900	. . .	. . .	. . . . .	Sub-soil of same (on limestone).
1571	Hardin	2.165		2.740		.180	.087	.067	a trace	.135	.072	94.290	.550	.800	.869	.236	. . . . .	Old field (on sandstone).
1572	Hardin	2.575		6.900		.045	.068	.102	a trace	.183	.045	89.940	.225	2.075	.485	.165	. . . . .	Sub-soil of same (on sandstone).

1634	Ohio	4.100	3.032	.170	.131	.093	not est	.125	a trace	92.455	.900	1.175	1.273	.814	. . . . .	Virgin soil, woodland (on sandstone).
1635	Ohio	3.500	7.047	.095	.258	.093	not est.	.273	0.144	88.841	.915	2.400	1.470	.617	. . . . .	Sub-soil of same (on sandstone).
1636	Ohio	3.550	4.066	.095	.104	.124	not est	.333	.012	91.990	.775	1.450	.939	.511	. . . . .	Old field (on sandstone).
1637	Ohio	3.350	6.475	.095	.171	.140	not est.	.269	.230	89.517	.775	2.575	1.107	.290	. . . . .	Sub-soil of same (on sandstone).
A. 12	St. of California	7.740	11.117	.790	1.596	.093	0.082	.727	.983	74.070	2.802		.814	.903	. . . . .	Adobe soil, Sacramento Valley.

*Total alkalies separated by fusion. †Silica separated by fusion with alkaline carbonates, &c.

TABLE II. LIMESTONES, &c., DRIED AT 212° F.

Number in report.	County.	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina.	Iron oxide.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Silica and silicates.	Per centage of lime.	Per centage of phosphorus.	Per centage of sulphur.	Remarks.
1313	Butler	not det.	93.020	2.088	0.917		0.243	0.604	not est.	not est.	2.760	52.091	0.106	0.242	S. C., Barren river, Airdrie Furnace.
1334	Campbell . . .	not det.	93.200	2.291	1.700		.076	.535	0.173	0.384	2.360	52.192	.033	.214	Lower Silurian.
1388	Carter.	2.624	97.720	not est.	0.300		.083	not est.	.115	.167	1.560	54.723	.036	not est.	Boone Furnace (flux).
1389	Carter.	2.700	95.150	.245	1.390		.130	a trace.	not est.	not est.	3.060	53.284	.056	a trace.	Iron Hills Furnace (flux).
1390	Carter.	not det.	75.750	.575	6.403		.057	.775	not est.	not est.	14.700	42.420	.032	.310	Mt. Savage Furnace (flux).
1421	Edmonson. . .	2.678	90.050	.363	0.511		.051	.260	.115	.327	1.060	50.428	.022	.104	Oolitic, sub-carboniferous.
1422	Edmonson. . .	2.721	77.550	13.314	2.680		.051	.192	.154	.188	6.060	43.428	.022	.077	Sub-carboniferous, upper part.
1423	Edmonson. . .	2.689	82.960	7.655	2.680		.115	.260	.135	.156	6.160	46.457	.050	.104	Sub-carboniferous, lithographic.
1426	Fayette	. . . .	. . . .	*.241	4.565		.415	.446	1.330	.099	6.130	68.804	. . . .	. . . .	Quicklime (Lower Silurian).
1426 *a*	Fayette	. . . .	96.610	.401	1.740		.057	not est.	.443	.275	.360	54.101	. . . .	. . . .	Impure calc. spar (Lower Silurian).
1498	Greenup. . . .	. . . .	88.140	.797	3.760		.178	.044	.269	.240	5.960	49.358	.077	.017	Pea Ridge (ferruginous).
1499	Greenup. . . .	2.680	88.150	.385	.152		.051	not est.	not est.	not est.	9.560	49.359	.022	not est.	Used as flux, Raccoon Furnace.
1500	Greenup. . . .	2.700	92.050	.220	1.490		.128	.199	. . . .	. . . .	4.460	51.548	.056	.079	Used as flux, Kenton Furnace.
1501	Greenup. . . .	2.770	60.750	25.656	4.167	†4.167	.013	.315	. . . .	. . . .	5.680	34.020	.005	.126	Buffalo Creek (ferruginous).
1587	Kenton	2.720	64.240	6.152	4.960		.191	not est.	.643	.260	23.860	35.974	. . . .	. . . .	Blue argillaceous (Lower Silurian).
1604	Montgomery. .	. . . .	. . . .	. . . .	.747		.023	not est.	.012	.011	.814	98.301	. . . .	. . . .	Quicklime (Star Lime Company).
1638	Bourbon. . . .	2.600	79.140	11.826	0.380	5.510	.511	.240	.231	.252	1.270	44.318	. . . .	. . . .	Cane Ridge limestone.

*Magnesia. †Iron carbonate.

TABLE III (A). IRON ORES (LIMONITES), DRIED AT 212° F.

Number in report.	County.	Iron peroxide.	Iron carbonate.	Alumina.	Manganese brown oxide.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Water (combined).	Silica and silicates.	Moisture and loss.	Per cent. of iron.	Per cent. of phosphorus.	Per cent. of sulphur.	Per cent of silica.	Remarks.
1269	Bath	76.077		2.592	0.430	0.130	0.281	0.731	0.030	12.300	8.180		53.254	0.319	0.011	6.160	Old Slate Furnace.
1273	Boyd	53.653		4.324	.308	a trace	.101	.313	.220	10.150	30.940		37.551	.137	.086	29.560	Slate ore, Cane Creek.
1274	Boyd	58.960		7.284	.380	.430	.227	.376	.206	10.800	21.210	0.127	41.272	.164	.082	19.980	Star Furnace yellow kidney.
1275	Boyd	51.802	10.569	4.523	a trace	7.480	.440	.570	.089	8.774	15.730		41.357	.231	.035	13.160	Bellefont Furnace limestone ore.
1276	Boyd	61.344		4.230	a trace	.750	.208	.795	.041	11.230	21.480		42.941	.347	.016	18.560	Buena Vista Furnace yellow kidney.
1277	Boyd	56.022	8.821	7.194	a trace	2.520	1.271	.526	.092	10.126	13.430		43.473	.229	.036	11.660	Buena Vista Furnace, Straight Creek.
1278	Boyd	54.055		4.919	.420	.080	a trace	.070	.096	10.450	30.080		37.838	.033	.038	24.260	Star Furnace black kidney.
1309	Butler	48.049		8.171	.140	.540	.195	.345	.473	9.750	31.900	.437	33.634	.150	.189	29.460	J. E. Taylor's (L. Reedy).
1310	Butler	44.794		2.391	a trace	.643	.234	.535	.158	7.900	44.180		31.482	.233	.063	42.200	Stevens' coal mine.
1371	Carter	81.640		3.160	a trace	.180	.919	.060	not est	11.280	2.600	.221	57.148	.026		not est	Horsley bank, Boone Furnace.
1372	Carter	52.460		7.504	a trace	a trace	.155	1.224	.268	12.360	25.360	.669	36.722	.534	.107	23.980	Main Block, Lambert.
1373	Carter	65.657		4.921	a trace	a trace	.040	.893	.604	10.740	17.780		45.959	.391	.241	15.960	Potato Knob ore.
1374	Carter	57.090		4.438	a trace	a trace	.086	.370	.391	11.100	26.760		39.963	.161	.156	22.256	Main Block, Stewart bank.
1375	Carter	38.285		5.455	.120	.460	.065	1.000	.071	9.500	44.760	.284	26.799	.436	.030	40.960	Royster Hill (Lambert).
1376	Carter	57.557		2.727	a trace	a trace	.065	1.746	.185	11.700	26.180		40.290	.762	.074		Smith Hill (German).
1377	Carter	52.736		3.531	.320	a trace	.065	.800	.171	10.700	31.840		36.815	.349	.068	27.360	Smith Hill crown ore.
1378	Carter	40.139	5.731	8.030	*.422	.380	*.254	.038	.177	7 715	37.220		29.816	.013	.071		Lower Block ore.
1379	Carter	56.670	8 538	4.405	.180	a trace	*.883	.337	.133	9.447	19.480		44.736	.147	.060		Lower Block ore.
1380	Carter	59.950		5.231		4.580	.343	.842	.845	11.860	16.860		41.965	.367	.335	16.860	Garvin's Hill Block.
1381	Carter	71.502		8.557	a trace	a trace	.054	.466	.800	9.500	9.030	.091	50.051	.203	.320	7.64	Old Mount Tom Main Block.
1382	Carter	61.316	19.435	3.537	a trace	a trace	.212	.166	1.009	3.545	10.780		48.585	.072	.403	9.960	Kibby Diggings Main Block.
1383	Carter	51.623		1.671	a trace	a trace	.483	.081	.498	9.230	36.830		36.136	.035	.163	11.560	Means & Russell's.
1384	Carter	71.680		4.155	0.090	0.380	.050	.084	.270	10.800	12.650		50.176	.036	.108	11.560	Graham Bank.
1385	Carter	66.200		3.907	.030	.430	.345	.133	.182	11.730	16.530	0.633	46.340	.057	.072	13.850	Mt. Savage yellow kidney.
1386	Carter	59.347	9.593	1.957	.030	.830	2.007	.153	.372	5.934	19.81		45.347	.069	.129	15.060	Stinson Creek Main Block.
1387	Carter	52.238		4.512	.130	.650	.041	1.693	.223	11.065	30.583		36.566	.740	.091	24.260	Clark's branch Tygert Creek.
1410	Edmonson	55.028		1.006	.040	a trace	.105	.312	.133	8.330	35.120		35.519	.135	.053	33.700	Bythe Meredith farm.
1411	Edmonson	76.284		2.361	.032	.180	.068	1.056	.151	12.080	7.951		53.399	.401	.059	7.660	Proctor ore bank.
1412	Edmonson	52.926		4.792	.210	.180	.425	.350	.143	10.400	30.580		37.048	.154	.057	29.160	Frederick's bank.
1445	Grayson	27.192		4.209	a trace	.410	.317	.249	.103	5.630	61.739	.110	19.344	.109	.041	25.500	Rock Creek.
1509	Greenup	80.040		2.682		a trace	.425	.115	.264	13.000	6.500		56.280	.050	.107		Limestone ore, Tygert Creek.
1510	Greenup	41.556		8.624		.180	not est	.882	.851	10.110	38.160		29.089	.358	.340		Lower Block, Tygert Creek.
1511	Greenup	60.576	15.623	2.860		a trace	.019	.632	not est	7.040	12.650		49.945	.267	not est		Limestone ore, Hood's Branch.
1512	Greenup	54.703	17.758	2.300	.440	.340	.499	.128	.685	7.194	15.958		46.865	.055	.272	12.960	Poynter Bank, Raccoon Furnace.
1513	Greenup	67.859		1.160	.980	.120	1.275	.143	not est	12.925	15.560		47.501	.062	not est	11.560	Limestone ore, Two Lick.
1514	Greenup	54.539		2.120	1.380	.040	1.823	.938	.336	10.910	28.360		38.171	.428	.134		Lower Block, Louder bank.
1515	Greenup	46.984	7.890	5.580	* 572	21.240	2.904	.371	not est	6.599	7.860		39.025	.162	not est		Limestone ore, Coon Fork.
1516	Greenup	72.957		1.660	.640	.380	.083	.500	.178	9.344	15.160		51.070	.218	.071		Limestone ore, Shover drift.
1517	Greenup	49.770		6.315	.640	.380	.115	.166	a trace	9.020	33.200	.394	34.839	.072	a trace	32.96	Limestone ore, Powder-mill Hollow.
1518	Greenup	50.006		8.317	a trace	.380	.291	.767	.356	11.760	28.820		35.004	.339	.142		Lower Block, J. Thompson's.
1519	Greenup	41.390		6.777	.180	a trace	.065	.579	.154	9.700	40.380	.775	28.973	.252	.061		Lower Block, Allen bank.

1520	Greenup. . . .	23.396	14.972	4.077	*.421	33.775	*.968	.537	.157	5.457	16.240	. . .	23.597	.224	.070	13.530	Main Block (calcareous).
1521	Greenup. . . .	68.928	. . .	2.708	.290	.680	.641	.249	.748	11.100	15.240	. . .	48.249	.098	.299	13.600	Main Block, L. Morton bank.
1522	Greenup. . . .	56.279	11.392	4.709	a trace	.180	.476	.601	.260	9.173	16.930	. . .	44.896	.262	.104	15.260	Kidney ore, Buffalo Farm.
1523	Greenup. . . .	56.840	not est	not est	not est	not est	not est	not est	not est	not est	not est	. . .	39.788	not est	not est	24.060	Main Block, Brushy Knob bank.
1524	Greenup. . . .	67.984	not est	not est	not est	not est	not est	not est	not est	not est	not est	. . .	47.589	not est	not est	12.900	Kidney ore, Osenton bank.
1525	Greenup. . . .	42.560	not est	not est	not est	not est	not est	not est	not est	not est	not est	. . .	29.792	not est	not est	40.160	Rough ore, Clay Lick Creek.
1526	Greenup. . . .	64.577	not est	not est	1.360	.440	.820	.172	.151	11.250	21.230	. . .	45.204	.075	.070	18.600	Kidney Block, McAllister Point.
1527	Greenup. . . .	36.985	not est	5.508	.040	.520	533	.367	.116	8.330	46.760	.810	25.889	.160	.040	44.460	Rough Block, below Main Block.
1528	Greenup. . . .	44.876	not est	4.083	.260	.990	.357	.166	.123	9.850	39 080	.215	31.413	.061	.049	35.960	Lower Block, Old Town Creek.
1529	Greenup. . . .	57.551	not est	6.017	.130	.150	.758	.057	.105	10.300	25.450	. . .	40.285	.025	.042	18.860	Limestone ore (slate ore).
1530	Greenup. . . .	60.206	not est	1.044	a trace	.285	.381	.101	.852	9.500	25.930	‡1.802	42.144	.070	.341	20.860	Lime kidney ore, Brush Creek.
1580	Hopkins . . .	50.850	. . .	5.462	a trace	3.129	1.546	.198	.189	10.530	27.683	.416	35.595	.086	.075	22.220	Ochreous, near St. Charles' mine.
1597	Lyon	59.37	. . .	1.622	.090	.170	.100	.179	.508	8.400	30.000	. . .	41.559	.077	.212	26.800	Suwannee Furnace (Big Showing).
1598	Lyon	70.518	. . .	.045	.090	.090	a trace	.275	.113	9.850	18.910	.009	49.363	.120	.045	18.160	Suwannee Furnace, bank near furnace.
1599	Lyon	66.117	. . .	1.064	.170	.090	a trace	.434	.213	9.800	22.230	. . .	46.819	.189	.083	21.160	Suwannee Furnace, railroad cut.
1600	Lyon	69.332	. . .	a trace	.170	.140	a trace	.330	a trace	9.550	20.500	. . .	48.574	.144	. . .	19.660	Suwannee Furn., Iron Mountain bank. Av'ge sample.
1605	Muhlenburg . .	3.043	. . .	5.220	.090	.630	.930	.147	.111	12.433	17.250	. . .	44.133	.064	.044	6.530	Airdrie Furnace (near No. 4 entry).
1606	Muhlenburg . .	60.492	. . .	7.075	.360	1.980	1.550	.083	.185	12.530	15.560	.185	42.344	.035	.074	13.600	From J. M. Hope's land, upper part.
1607	Muhlenburg . .	46.866	. . .	5.930	.103	2.535	1.073	.179	.059	9.550	33.530	.175	32.820	.078	.024	32.860	From J. M. Hope's land. Average sample.
1608	Muhlenburg . .	69.546	. . .	3.914	.230	.480	.921	.115	.216	11.250	12.730	.598	48.822	.050	.086	11.300	Martin ore.
1609	Muhlenburg . .	59 810	. . .	2.972	.720	†2.263	4.270	.223	.005	.200	29.880	. . .	41.867	.097	.026	25.260	Roasted ore, Airdrie Furnace.
1640	Edmonson. . .	7.340	. . .	5.930	not est	1.090	.447	1.060	not est	12.380	51.230	not est	19.138	.497	. . .	not est	Near Nolin Furnace.
1641	Grayson. . . .	57.830	. . .	6.719	not est	.290	.122	.921	not est	12.180	21.040	.898	40.481	.412	not est	14.360	Near Nolin Furnace, Brownsville road.
1642	Grayson. . . .	44.528	. . .	1.368	not est	5.590	.609	1.074	.151	8.940	37.380	.360	31.169	.468	.060	not est	Taylor's Fork, Bear Creek.

*Carbonates. †Lime. ‡And carbonic acid.

TABLE III (B). IRON ORES (CLAY IRON-STONES), DRIED AT 212° F.

Number in Report.	County.	Specific gravity.	Iron carbonate.	Iron peroxide.	Alumina.	Lime carbonate.	Magnesia carbonate.	Manganese carbonate.	Phosphoric acid.	Sulphuric acid.	Silica and silicates.	Water and loss.	Per cent. of iron.	Per cent. of phosphorus.	Per cent. of sulphur.	Per cent. of silica.	Remarks.
1270	Boyd	. . .	32.285	12.784	11.963	21.125	0.691	0.465	0.377	0.267	19.730	0.308	24.591	0.164	0.107	. . .	J. P. Jones' drift.
1271	Boyd	3.361	36.854	.276	4.264	2.464	4.086	.572	.709	.885	18.360	1.538	32.466	.348	.354	15.50	Wilson Creek Blue Block, Star Furnace.
1272	Boyd	. . .	19.802	21.433	1.193	30.205	a trace	.242	.257	.157	23.080	3.033	23.109	.112	.063	18.96	Williams' Creek limestone ore, Star Furnace.
1311	Butler	. . .	29.914	17.945	3.583	12.036	3.677	a trace	.467	.381	28.040	3.957	27.041	.204	.152	25.20	John Hudson's.
1312	Butler	. . .	22.583	17.313	.835	6.714	2.830	a trace	.972	.473	44.240	4.040	22.909	.423	.189	42.76	Knob Lick.
1361	Carter	2.879	24.408	. . .	.560	45.200	24.328	.391	.147	.439	2.420	1.768	10.962	.064	.203	not est	Ferruginous limestone.
1362	Carter	. . .	61.224	4.410	2.260	4.480	a trace	.150	.313	not est	21.260	5.367	32.570	.136	. . .	not est	Old Orchard diggings.
1363	Carter	. . .	62.604	10.024	1.630	.240	2.838	3.251	.127	.521	13.720	3.017	37.205	.055	.208	not est	Old Orchard diggings.
1364	Carter	. . .	65.018	5.945	1.090	2.720	9.036	2.332	.255	1.280	10.260	. . .	35.549	.111	.533	not est	Horsley bank.
1365	Carter	. . .	44.242	27.296	1.560	6.580	1.040	.842	.732	4.587	11.160	1.955	40.405	.321	1.855	not est	Horsley bank.
1366	Carter	. . .	27.511	26.240	9.021	2.320	2.838	.270	.499	.116	25.180	6.005	31.593	.208	.040	23.84	Tygert Creek.
1367	Carter	. . .	62.321	4.989	7.901	12.00	.222	.121	.684	.200	10.740	.810	33.348	.298	.082	8.98	Sinking Creek.
1368	Carter	. . .	46.893	9.255	5.703	12.460	.250	not est	.978	a trace	23.510	.951	29.116	.427	. . .	20.86	Foxden ore.
1369	Carter	. . .	30.708	31.544	1.779	2.730	.144	.060	.421	.491	25.430	6.523	36.627	.184	.196	10.56	Mt. Savage Furnace.
1370	Carter	. . .	47.391	9.734	4.197	5.220	7.893	.346	.121	.151	20.230	4.717	29.685	.052	.063	19.70	Barrett's Creek.
1444	*Grayson	. . .	60.469	6.530	7.179	4.050	6.378	a trace	.102	.054	14.450	.785	33.630	.035	.022	11.90	J. H. Higden's.
1502	Greenup	3.280	54.773	8.648	7.800	3.780	3.088	1.204	.447	.298	20.250	. . .	29.851	.195	.105	18.56	Lower Block, Alcorn Creek.
1503	Greenup	3.297	78.722	.204	2.746	2.250	.380	.421	.595	1.160	11.340	2.272	38.130	.221	.524	9.74	Blue Kidney, Kenton Furnace.
1504	Greenup	. . .	33.321	21.274	4.991	.980	.439	a trace	.434	1.208	31.730	5.647	30.975	.189	.443	29.52	Main Block, Amanda Furnace.
1505	Greenup	. . .	30.510	14.271	6.197	16.980	.591	a trace	.614	2.332	28.980	. . .	22.270	.267	.905	27.39	Conglomerate ore, Buffalo Furnace.
1506	Greenup	3.263	14.678	6.500	4.178	2.230	1.903	a trace	.204	.252	36.830	3.177	26.073	.089	.104	34.362	Lower Block ore, Womack's bank.
1507	Greenup	not de	55.258	13.468	.670	4.880	4.528	.060	.368	1.043	15.060	4.065	36.103	.200	.410	13.362	Main Block or grey ore, Laurel Furnace.
1508	Greenup	not de	64.024	4.044	4.414	1.340	.836	not est	.217	.503	20.310	3.650	33.627	.095	.225	14.440	Grey ore, Raccoon Furnace
1610	Muhlenburg	3.376	47.810	9.054	5.205	3.740	7.180	0.797	.179	.237	17.010	8.788	29.418	.078	.094	12.970	"Black-band ore," Airdrie Furnace.
1611	Muhlenburg	not de	42.953	29.513	2.151	2.420	4.322	1.063	.068	1.570	9.093	5.809	30.916	.035	.638	6.224	"Slate Iron ore," Buckner Furnace.
1612	Muhlenburg	not de	16.045	13.374	6.540	13.430	5.623	a trace	.211	.153	22.230	6.061	27.134	.092	.071	20.660	Jerry Hope's bank (lower part).
1644	Grayson	not de	19.598	42.701	4.994	2.840	not est	not est	1.017	a trace	20.830	8.054	37.945	.444	a trace	not est	"Glady ore," west of Bear Creek.

*See 1644.

TABLE IV. COALS, AIR-DRIED.

Number in Report.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Carbon in the coke.	Ashes.	Character of the coke.	Color of the ash.	Per centage of sulphur.	Remarks.
1279	Boyd	1.328	6.50	33.90	59.60	40.40	52.78	6.82	Dense.	Light lilac-grey	3.765	Buena Vista Furnace (coal 7), Straight Creek.
1280a	Boyd	1.358	3.40	32.30	64.30	35.70	55.40	8.90	Dense.	Light purple-grey	1.230	Bellefont Furnace coal 6, Turkey-pen Hollow.
1280b	Boyd	not est	4.70	34.30	61.00	39.00	59.04	1.96			.932	Bellefont Furnace coal 6). Selected sample.
1281	Boyd	1.304	3.50	34.10	62.34	37.66	55.30	7.19	Dense.	Purple-grey	2.370	Chadwick Creek (coal, No. 7).
1282	Boyd	1.364	3.20	32.30	64.50	35.50	53.00	11.50	Dense.	Lilac-grey	1.000	Buena Vista Furnace, Straight Creek (coal 5).
1283	Boyd	1.279	2.94	32.56	64.50	35.50	56.76	7.74	Spongy	Lilac-grey	1.072	Key's Creek coal.
1284	Boyd	1.366	3.20	29.70	67.10	32.90	55.10	12.00	Friable	Drab-grey	1.793	Bellefont Furnace, Hood's Creek (coal 3).
1285	Boyd	1.315	2.70	36.70	60.60	39.40	52.60	8.00	Spongy	Dark lilac grey	1.711	Horse Run coal (No. 6).
1286	Boyd	1.308	3.30	33.30	63.40	36.60	57.60	5.80	Moderately dense.	Light lilac-grey	2.48	Ashland Company, mine 4, Coalton (No. 7).
1287	Boyd	1.340	4.40	31.10	64.50	35.50	57.90	6.00	Spongy	Lilac-grey	2.098	Ashland Company, Dry Branch (No. 7).
1288	Boyd	1.336	4.00	34.24	61.70	38.30	54.70	7.00	Spongy	Lilac-grey	1.854	Ashland Company, Trace Creek (No. 7).
1289	Boyd	1.320	5.00	34.50	60.50	39.50	55.40	5.10	Spongy	Light brown-grey	1.285	Ashland Company (Coalton, No. 7).
1290	Boyd	1.365	4.00	34.06	61.94	38.06	53.20	8.74	Spongy	Dove colored	1.890	Mr. Bryan's bank, Four-mile Creek (No. 7).
1291	* Boyd	1.404	2.60	35.80	61.60	38.40	40.86	14.74	Spongy	Brownish-grey	5.361	W A Belt's coal, Little Sandy (No. 11).
1313	Butler	1.378	3.40	30.06	65.94	34.06	54.94	11.00	Spongy	Brownish lilac-grey	2.541	Stevens' coal, Bear Creek.
1344	Carter	1.330	7.00	36.26	50.74	43.20	44.04	12.10	Pulverulent	Nearly white	not est	Old Orchard diggings (sub-conglomerate?).
1345	Carter	1.377	7.70	28.10	64.14	35.86	53.04	11.10	Very friable	Lilac-grey	1.055	Star Furnace (coal, No. 7, upper layer).
1346	Carter	1.288	6.60	34.30	59.04	40.96	54.60	4.40	Dense porous	Lilac-grey	.724	Star Furnace (bottom layer).
1347	Carter	1.290	6.40	27.22	66.38	33.62	58.88	7.50	Very friable	Light-brown	.973	Star Furnace (middle layer).
1346d	Carter	1.435	5.40	32.70	61.90	38.10	52.52	9.58	Dense porous	Lilac-grey	2.356	W. Pritchard's bank (No. 7 coal).
1348b	Carter	not est	4.50	37.10	58.40	41.60	56.40	2.00			.571	W. Pritchard's bank. A selected sample.
1349	Carter	1.347	6.90	33.96	59.14	40.86	51.04	8.10	Dense porous	Yellowish lilac-grey	2.430	Mt. Savage property (coal, No. 7).
1350	Carter	1.340	6.40	31.40	62.20	37.80	57.60	4.54	Dense porous	Purplish-grey	1.070	Mt. Savage property (coal, No. 7, lower part).
1351	Carter	1.323	6.00	32.94	61.00	39.00	54.84	6.20	Dense porous	Dark purplish-grey	1.867	Mt. Savage property (coal, No. 7, upper part).
1352	Carter	1.326	4.40	33.60	62.00	38.00	52.86	9.14	Dense porous	Brownish-grey	2.210	Watson's bank, No. 7 coal, "Coalton" Creek.
1353	Carter	1.274	3.80	34.50	61.70	38.30	58.50	3.20	Dense porous	Brownish-grey	2.104	Graham bank, coal, No. 1, near Willard.
1354	Carter	1.352	3.20	35.00	61.74	38.26	54.40	7.34	Spongy	Lilac grey	2.631	Coal, No. 7, "Coalton" coal, west of Dry Fork.
1355	Carter	1.337	3.70	35.96	60.34	39.66	52.94	7.40	Dense spongy	Grey-brown	2.727	Coal, No. 7, "Coalton" coal, old Lost Creek drift.
1356	Carter	1.289	4.10	34.00	61.30	38.70	56.523	7.775	Dense porous	Lilac-grey	1.414	Coal, No. 2, Kibby drift, Everman's Creek.
1357	Carter	1.298	4.60	33.50	61.90	38.10	51.60	10.30	Dense porous	Yellowish-grey	1.200	Coal, No. 1, Stone-coal, branch of Tygert's Creek.
1358	Carter	1.307	4.20	33.76	62.10	37.90	51.44	10.70	Spongy	Brownish-grey	3.483	Coal, No. 2? Barrett's Creek.
1359	Carter	1.388	3.00	36.20	60.80	39.20	49.24	11.50	Spongy	Lilac-grey	1.361	Coal, No. 3? Carter farm, near Grayson.
1360	† Carter		2.46	1.84	95.70	4.30	87.34	8.36	Dense spongy	Lilac-grey	2.026	Coke, from No. 7 coal, Willard.
1413	Edmonson	1.282	2.30	32.10	65.60	35.40	56.34	9.30	Cellular	Light lilac-grey	1.059	Tar Lick coal, five and a half feet thick.
1414	Edmonson	1.350	3.60	33.00	63.40	36.60	54.40	9.00	Spongy	Lilac-grey	2.101	Mill Branch.
1415	Edmonson	1.367	3.20	33.80	63.00	37.00	52.60	10.40	Moderately dense	Lilac-grey	2.923	Mill Branch (much weathered).
1416	Edmonson	1.345	2.60	33.80	63.60	36.40	53.14	10.46	Spongy	Light lilac-grey	2.475	Knob Lick, Dismal Creek.
1417	Edmonson	1.429	1.20	39.00	59.80	40.20	45.46	14.34	Dense	Dark grey-purple	8.685	and 0.178 phosphoric acid. Gross, Bear Creek.
1418	Edmonson	1.330	3.60	35.14	61.20	38.80	54.20	6.94	Light cellular	Lilac-grey	2.706	Shoal Branch
1419	Edmonson	1.335	4.06	33.24	62.70	37.30	51.70	11.00	Spongy	Light lilac-grey	1.670	Tar Lick, branch of Davis Creek.
1420	Edmonson	1.437	4.00	32.00	63.94	36.06	50.84	13.10	Light spongy	Grey-lilac	4.938	Mill branch of Bear Creek.

TABLE IV. COALS, AIR-DRIED.—(Continued.)

Number in Report.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Carbon in the coke.	Ashes.	Character of the coke.	Color of the ash.	Per centage of sulphur.	Remarks.
1448	Grayson. . . .	1.395	4.70	31.40	63.90	36.10	52.20	11.70	Spongy	Light brownish-grey .	1.945	Tar Lick Coal, Dismal Creek.
1449	Grayson. . . .	1.393	4.14	30.52	65.34	34.66	50.08	15.26	Dense spongy . . .	Brownish-grey. . . .	3.563	Gravelly Lick, Miller's Fork of Bear Creek.
1450	Grayson. . . .	1.346	6.26	32.44	61.3	38.7	53.8	7.5	Light friable. . . .	Greyish-salmon . . .	1.476	Brushy branch of Calloway Creek.
1451	Grayson. . . .	1.378	3.50	33.40	63.10	36.90	47.50	15.60	Light spongy . . .	Lilac-grey	2.041	Copperas bank, branch of Hunting Fork of Rock Creek.
1452	Grayson. . . .	1.364	3.60	35.8	60.6	39.4	49.4	11.2	Light spongy . . .	Light-chocolate . . .	3.158	L. Higdon's, sub-conglomerate.
1453	Grayson. . . .	1.446	6.50	29.1	64.40	35.60	49.60	14.80	Friable	Light-brownish . . .	.818	Gum Spring Fork of Cane Camp Creek.
1454	Grayson. . . .	1.512	4.40	25.86	69.74	30.26	40.14	29.60	Friable	Nearly white	.777	Gum Spring Fork (below slate parting).
1455	Grayson. . . .	1.338	4.44	30.82	64.94	35.06	55.52	9.42	Light friable. . . .	Brownish salmon-grey	2.892	In the sub-carboniferous limestone.
1484	Greenup. . . .	1.316	4.82	32.90	62.28	37.72	55.18	7.10	Friable	Chocolate	1.409	Coal, No. 1, Kenton Furnace.
1485	Greenup. . . .	1.345	4.96	32.93	62.06	37.94	55.46	6.60	Light spongy . . .	Lilac-grey	4.774	J. Thompson's bank, Kenton Furnace (sixteen inches).
1480	Greenup. . . .	1.250	4.80	34.04	60.5	39.44	52.58	7.98	Dense.	Lilac grey	1.331	Coal, No. 3, Main coal, average sample, Raccoon Furn.
1487	Greenup. . . .	1.422	4.28	36.52	59.20	40.80	47.00	12.20	Dense.	Lilac grey	5.934	Coal, No. 3 (upper part), Raccoon Furnace.
1488	Greenup. . . .	1.374	3.24	30.20	66.56	33.44	47.54	13.0	Spongy	Dark lilac-grey . . .	3.647	Coal, No 3 (lower part), Raccoon Furnace.
1489	Greenup. . . .	1.385	2.94	33.76	63.34	36.66	51.34	12.00	Dense.	Dark lilac-grey . . .	4.911	Coal, No. 3 (above shale parting), Raccoon Furnace.
1490	Greenup. . . .	1.374	3.30	31.9	64.8	35.20	52.20	12.6	Friable	Lilac-grey	2.507	Alcorn Creek, probably sub-conglomerate.
1491	Greenup. . . .	1.385	4.06	31.66	64.34	35.66	53.44	10.90	Spongy	Dark lilac-grey . . .	4.633	Hanna bank (average of upper portion).
1492	Greenup. . . .	1.295	3.20	33.90	62.90	37.10	50.7	6.20	Spongy	Lilac-grey	0.740	Hanna bank (average of lower portion).
1493	Greenup. . . .	1.289	4.16	34.06	61.94	39.06	55.54	5.40	Spongy	Dark-brick	1.590	Coal (No. 3?), Laurel Furnace.
1494	Greenup. . . .	1.315	4.04	33.62	62.34	37.6	53.34	9.02	Dense	Light lilac-grey . . .	1.318	Coal, No. 6, Amanda Furnace.
1495	Greenup. . . .	1.305	4.30	35.60	60.10	39.90	52.24	9.86	Spongy	Grey-purple	5.263	Coal, No. 6, Hunnewell Furnace.
1496	Greenup. . . .	1.300	3.20	30.60	62.20	33.8	53.14	7.06	Dense spongy . . .	Lilac-grey	2.264	Coal, No. 6, Pennsylvania Furnace.
1497	‡Greenup . . .	1.355	3.8	37.70	58.50	41.50	47.20	11.3	Spongy	Dark brownish-purple	4.213	Coal, No. 6, Hunnewell Furnace (new bed).
1578	Hopkins . . .	1.448	3.40	30.0	66.60	33.40	51.1	15.50	Spongy	Dark grey-purple . .	7.280	Wm. Mills' coal, Nortonsville.
1579	Hopkins . . .	1.342	3.20	35.90	60.90	39.10	54.04	6.90	Light spongy . . .	Light lilac-grey . . .	2.759	St. Charles' mines.
1588	Lawrence . . .	1.316	4.60	35.7	59.70	40.3	52.22	6.42	Spongy	Light lilac-grey . . .	1.080	McHenry's coal bank (No. 3), near Louisa.
1589	Lawrence . . .	1.281	5.10	35.3	59.6	40.4	57.82	1.8	Light spongy . . .	Light grey-buff . . .	.730	F. Swetman's bank (Coal, No. 1), Brushy Creek.
1590	Lawrence . . .	1.376	3.30	35.10	61.54	38.46	47.84	13.70	Dense spongy . . .	Dark lilac-grey . . .	2.109	Coal, No. 1, Boggs' Mill, Cane's Creek.
1591	Lawrence . . .	1.340	2.10	33.0	64.90	36.00	50.00	8.00	Friable	Yellowish-white . . .	.750	Coal, No. 3, Holbrook's coal, Brushy Creek.
1592	Lawrence . . .	1.359	2.50	36.50	58.94	41.06	51.44	7.50	Light spongy . . .	Grey-purple	3.785	Coal, No. 3, Mr. Bogg's bank, upper part.
1593	Lawrence . . .	1.284	2.50	39.00	58.50	41.50	54.7	3.74	Spongy	Brownish-grey . . .	1.060	Coal, No. 3, Mr. Bogg's bank, lower part.
1601	Menifee	1.319	2.94	33.96	64.10	36.08	50.62	7.40	Dense	Light brownish-grey .	.997	Sub-conglomerate, Hawkins' Creek.
1602	Menifee	not est	2.66	34.04	63.3	36.70	50.24	13.06	Dense.	Dark lilac-grey . . .	4.092	Sub-conglomerate, on Ledford's land.
1603	Menifee	not est	2.83	15.2	82.0	18.00	24.30	57 7	Pulverulent	White.	not est	Bituminous shale above S. C. limestone.
1617	Muhlenburg . .	not est	7.50	4.2	88.3	11.7	82.9	5.4	. . . . .	Light yellowish-grey .	.640	Coke, from No. 12 coal (sixteen years weathered).
1618	Muhlenburg . .	1.278	3.60	31.40	65.00	35.0	58.50	6.50	Dense spongy . . .	Lilac-grey	1.438	Coal, No. 12, Airdrie Furnace. Average sample.
1619	Muhlenburg . .	1.332	4.70	30.60	64.70	35.30	58.80	5.90	Dense spongy . . .	Light lilac-grey . . .	1.455	Coal, No. 12, Airdrie Furnace, weathered eighteen years.
1620	Muhlenburg . .	1.331	4.20	36.10	59.70	40.30	50.50	9.20	Spongy	Dark lilac grey . . .	4.573	Paradise mine (Airdrie), coal 11, lower division.
1621	Muhlenburg . .	1.326	4.10	35.90	60.00	40.00	53.60	6.40	Spongy	Dark lilac-grey . . .	4.394	Paradise mine (Airdrie), middle layer.
1622	Muhlenburg . .	1.274	3.60	38.70	56.70	42.30	53.70	4.60	Spongy	Light lilac-grey . . .	3.158	Paradise mine (Airdrie), upper layer.
1623	Muhlenburg . .	1.221	3.80	32.70	63.50	36.50	58.60	4.90	Dense spongy . . .	Brownish salmon-grey	1.923	Muddy river coal mine.
1624	Muhlenburg . .	1.407	4.16	37.44	58.40	41.60	49.80	8.60	Light spongy . . .	Light lilac-grey . . .	2.727	Ross' coal mine, upper portion.

1625	Muhlenburg . .	1.358	3.60	34.00	62.40	37.60	50.60	11.80	Light spongy . . .	Lilac-grey	4.032	Mercer coal mines.
1626	Muhlenburg . .	1.279	3.10	40.68	56.22	43.78	50.66	5.56	Spongy	Lilac grey	2.779	Muhlenburg coal mines, upper seam.
1627	Muhlenburg . .	1.332	1.52	40.00	58.48	41.52	50.92	7.56	Spongy	Lilac-grey	2.840	Muhlenburg coal mines, main working bed.
1628	Muhlenburg . .	1.280	2.98	43.08	53.94	46.06	50.22	3.74	Spongy	Lavender-grey . . .	3.125	Muhlenburg coal mines, average head of main entry.
1629	Muhlenburg . .	1.503	1.20	7.50	91.30	8.70	86.48	4.82	Powdery	Dark-brown	3.431	Fibrous coal or mineral charcoal.
1630	Muhlenburg . .	not est	3.56	13.68	82.76	17.24	6.82	75.94	Powdery	Brownish-grey . . .	1.983	Carbonaceous mud.
1631	Ohio	1.421	3.50	35.00	61.50	38.50	52.50	9 00	Light spongy . . .	Light brownish-grey .	3.139	Rockport coal mines, average sample along entry.
1632	Ohio	1.332	3.00	36.20	60.80	39.20	53.70	7.10	Light spongy . . .	Light lilac-grey . . .	2.837	Rockport coal mines, general average of mine.
1633	‡Ohio	1.334	3.00	33.50	63.50	56.50	55.10	8.40	Light spongy . . .	Lilac-grey	3.332	Rockport coal mines.
A. 1	State of Ohio .	1.361	4 54	29.08	65.78	34.22	57.06	8.72	Pulverulent . . .	Nearly white	.756	Star Furnace coal, Jackson county, Ohio.
A 2	State of Ohio .	1.322	3.00	33.42	62.98	37.02	55.82	7.16	Dense.	Brownish-grey . . .	.862	Hocking Valley coal, average sample whole bed.
A. 3	State of Ohio .	not est	4.20	36.68	59.12	40.88	54.16	4.96	Spongy	Light lilac grey . . .	1.692	Hocking Valley (stock pile), average sample.
A. 4	State of Ohio .	1.346	3.26	33.76	62.98	37.02	54.42	8.50	Dense.	Light lilac-grey . . .	2.247	Hocking Valley, average of upper twenty-eight inches.
A. 5	State of Ohio .	1.303	3.74	36.32	59.94	40.06	55.74	4.20	Dense spongy . . .	Light lilac-grey . . .	1.299	Hocking Valley, average of middle twenty-six inches.
A. 6	State of Ohio .	1.312	4.40	35.08	60.52	39.48	55.20	5.32	Dense spongy . . .	Light lilac-grey . . .	1.659	Hocking Valley, average of lower eighteen inches.
A. 12	State of Ohio .	1.312	3.46	36.64	59.90	40.10	53.80	6.10	Light spongy . . .	Light lilac-grey . . .	1.947	Sheridan coal mines, Lawrence county, Ohio.
A. 7	State of Illinois	1 310	2.64	32.04	65.34	34.06	58.58	6.76	Light spongy . . .	Lilac-grey	2.472	Big Muddy coal, Jackson county, Illinois.
A. 8	State of Illinois	1.310	3.44	31.86	64.70	35.30	59.54	5.10	Spongy	Lilac-grey	1.376	Big Muddy coal, Jackson county, Illinois.
A 9	State of Indiana	1.313	2.70	36.38	60.92	39.08	55.64	5.28	Spongy	Lilac-grey	1.664	Indiana Block coal, near Brazil, Clay county.
A. 10	State of Indiana	not est	2.68	36.32	61.00	39.00	53.58	7.42	Dense spongy . . .	Light lilac-grey . . .	1.802	Indiana Block coal.
A. 11	State of Indiana	not est	2.40	35.10	62.50	37.50	53.50	9.00	Dense.	Lilac-grey	2.373	Indiana Block coal, lower seam.
1645	Boyd	1.291	4.80	34.20	61.00	39.00	54.90	6.10	Spongy	Light brownish-grey .	1.312	Coal, No. 7, used at Ashland Furnace.
1646	Carter.	1.269	3.50	36.30	60.20	39.80	57.30	2.90	Spongy	Brownish-grey . . .	1.148	Coal, No. 1, Graham bank.
1647	Carter.	not est	3.60	35.40	61.00	39.00	57.60	3.40	Spongy	Brownish-grey . . .	1.107	Coal, No. 1, Graham bank.
1648	Greenup. . . .	1.409	4.10	28.9	67.00	33.00	49.60	17.40	Pulverulent	Nearly white (l't-grey)	.655	Coal, No. 1, Raccoon Creek.
1649	Greenup. . . .	1.306	1.50	52.20	46.30	53.70	40.60	5.70	Very friable	Light yellowish-grey .	.782	Cannel coal, Hunnewell mine.
1650	Ohio	1.315	3.30	35.84	60.86	39.14	54.36	6.50	Spongy	Chocolate-grey. . . .	3.874	Coal D, Taylor's coal mines.
1651	Ohio	1.316	3.30	30.76	59.94	40.06	52.60	7.34	Spongy	Brownish-grey . . .	2.608	Coal D, Stevens' coal mines.

*See 1645. †See 1646. ‡See 1648. §See 1650.

TABLE V (A). MARLY SHALES, MARLES, SILICIOUS CONCRETIONS, &c., DRIED AT 212° F.

Number in Report.	County.	Silica and silicates.	Silica.	Alumina.	Iron oxide.	Lime carbonate.	Lime.	Magnesia carbonate.	Magnesia.	Phosph'ic acid.	Sulphuric acid.	Potash.*	Soda.*	Total potash.	Total soda.	Water, &c.	Remarks.
1292	Boyd	77.560	. . .	12.643		0.480	. . .	.929	. . .	.217	.070	1.387	.080	3.989	.639	5.830	Marly shale, near Clinton Furnace.
1307	Bracken		76.060	14.959		.530	. . .	.345	. . .	.486	a trace	. . .	. . .	2.735	1.515	3.400	Silicious mudstone.
1308	Breckinridge	66.680	. . .	20.860		1.060	. . .	. . .	0.684	.230	.061	. . .	. . .	.092	.501	. . .	Red under clay (ferruginous).
1315	Campbell		47.320	28.050		13.190	. . .	1.135	. . .	.345	not est	. . .	. . .	3.254	.641	4.800	Marly shale, Cincinnati Group.
1316	Campbell		68.760	12.050		9.560	. . .	3.850	. . .	.223	not est	. . .	. . .	1.329	.97	2.200	Marl (mudstone).
1317	Campbell		58.080	31.490		.660	. . .	1.135	. . .	.255	not est	. . .	. . .	3.045	.980	4.700	Clay shale, Newport Reservoir.
1318	Campbell		51.420	29.450		6.850	. . .	1.256	. . .	.122	not est	. . .	. . .	4.124	.567	4.400	Clay shale, Newport Reservoir.
1319	Campbell		72.660	20.500		a trace	. . .	.832	. . .	.102	not est	. . .	. . .	1.243	not est	4.200	Clay, brick clay.
1320	Campbell		82.560	12.223		.160	. . .	a trace	. . .	not est	not est	. . .	. . .	.675	.282	4.100	Sandy, ferruginous clay.
1321	Campbell		57.160	33.540		.860	. . .	1.776	. . .	not est	not est	. . .	. . .	2.698	.555	3.411	Ferruginous clay.
1322	Campbell		81.660	12.700		a trace	. . .	a trace	. . .	a trace	not est	. . .	. . .	.756	.037	4.400	Sand, moulding sand.
1323	Campbell		85.840	3.500		7.400	. . .	not est	. . .	not est	not est	. . .	. . .	not est	not est	2.200	Sand, beneath brick clay.
1335	Campbell		54.160	12.260	15.550	7.800	. . .	.165	. . .	.281	.659	. . .	. . .	3.298	.926	4.872	Marly shale, Cincinnati Group.
1336	Campbell		57.260	16.782	11.500	4.560	. . .	.778	. . .	.008	.233	. . .	. . .	4.471	1.072	3.336	Marly shale, Cincinnati Group.
1409	Carter		84.000	11.500		.560	. . .	. . .	. . .	.121	.223	not est	. . .	. . .	.366	.587	2.500	Sandy sub-soil, Little Sandy river.
1431	Franklin	77.380	. . .	10.415		1.440	. . .	. . .	. . .	.80	.435	.735	3.483	.042	8.479	.696	5.350	Green marly shale.
1432	Franklin	70.060	. . .	15.395		. . .	.875	. . .	2.295	.470	.570	3.565	.318	7.130	.740	6.400	Olive marly shale.
1433	Franklin		50.360	16.816	6.797	. . .	8.774	. . .	.930	.217	2.28	. . .	. . .	3.623	1.731	8.304	Marly shale (mineral paint).
1434	Franklin		52.660	18.831	9.200	. . .	3.660	. . .	1.210	.319	.920	. . .	. . .	5.492	.720	7.672	Marly shale (mineral paint).
1439	Fulton		74.960	18.350		.560	. . .	. . .	. . .	.300	.051	.501	. . .	.231	.124	5.800	Silicious clay (indurated).
1440	Fulton		81.060	13.689		.560	. . .	. . .	. . .	.139	.051	.844	. . .	.231	.021	3.600	Soft sandstone or silicious concretion.
1441	Fulton		89.160	7.889		.380	. . .	. . .	. . .	.080	.051	.707	. . .	.115	.068	2.400	Soft sandstone or silicious concretion.
1442	Fulton		94.000	3.129		.380	. . .	. . .	. . .	.173	.051	.961	. . .	.230	.124	1.600	Soft sandstone or silicious concretion.
1443	Illinois		70.660	20.309		.960	. . .	. . .	. . .	.307	.051	1.188	. . .	.819	.487	5.210	Post Tertiary clay, Grand Chain.
1446	Grayson	71.560	. . .	19.133		. . .	.269	. . .	.353	.207	.027	2.910	.052	4.115	.602	6.230	Marly shale, Sunset Lick.
1446	Grayson		60.060	14.130	13.480	. . .	.538	. . .	1.158	.280	.204	. . .	. . .	4.625	.783	6.000	Same, analyzed by fusion.
1447	Grayson	87.700	. . .	7.040		.100	. . .	. . .	. . .	.245	.370	.049	.975	.401	. . .	. . .	3.000	Soft sandstone, Horse Branch.
1577	Henry		23.700	7.146	11.040	44.560	. . .	. . .	. . .	.310	1.164	.961	. . .	. . .	2.100	.623	8.396	Marl (cut of Cumberland & Ohio Railr'd, Eminence).
1581	Kenton		77.460	16.500		.480	. . .	. . .	. . .	.121	not est	not est	. . .	. . .	.828	.580	4.500	Silicious grit.
1582	Kenton		75.700	15.793		.660	. . .	. . .	. . .	.214	.609	not est	. . .	. . .	.847	.762	5.100	Silicious grit.
1583	Kenton		56.400	29.971		.760	. . .	. . .	. . .	1.514	.100	not est	. . .	. . .	2.538	.551	7.100	Marly clay, Cincinnati Group, Lower Silurian.
1584	Kenton		68.360	22.256		1.000	. . .	. . .	. . .	1.181	.258	not est	. . .	. . .	2.139	.906	3.650	Brick clay.
1585	Kenton		43.461	21.000		.680	. . .	. . .	. . .	.686	.607	not est	. . .	. . .	2.447	.915	3.850	Marly shale, Cincinnati Group.
1586	Kenton		47.160	22.850		.840	. . .	. . .	. . .	.840	.128	not est	. . .	. . .	2.301	1.593	5.200	Marly shale, Cincinnati Group.

* Extracted by digestion in acids.

TABLE V (B). CLAYS, &c., DRIED AT 212° F.

Number in Report.	County.	Silica.	Alumina.	Iron oxide.	Lime.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Water expelled at red heat.	Remarks.
1337	Carter.	48.560	37.471	a trace.	.112	a trace.	.255	not est.	.289	.283	13.030	Fire-clay, Boone Furnace property.
1338	Carter.	45.960	38.531	a trace.	.145	a trace.	.563	not est.	.250	.341	14.210	Fire-clay, Boone Furnace property.
1339	Carter.	54.620	32.466	a trace.	a trace.	a trace.	.243	not est.	.212	.679	11.780	Fire-clay, Boone Furnace property.
1340	Carter.	62.460	27.203	a trace.	a trace.	a trace.	.147	not est.	1.850	.584	7.756	Fire-clay, under coal, Old Orchard diggings, Boone Furn. property.
1341	Carter.	45.560	43.775	a trace.	.145	a trace.	.307	not est.	.963	.728	8.522	Fire-clay, Boone Furnace property.
1342	Carter.	64.260	24.604	not est.	.538	.209	.946	.157	.751	.515	8.300	Fire-clay, under twelve inch coal, Geo. Ossenton's.
1343	Carter.	66.060	23.726	not est.	*.300	*.121	.127	not est.	2.093	2.273	5.300	Clay shale, Grayson.
(*a.*)	France	48.680	36.920	not est.	not est.	.520	not est.	not est.	not est	not est.	13.130	Porcelain clay, of St. Yrieix.
(*b.*)	China	55.300	30.300	2.000	not est.	.400	not est.	not est.	1.100	not est.	8.200	Porcelain clay, of China.
(*c.*)	England. . . .	63.400	31.700	3.000	not est.	not est.	not est.	not est.	1.900		not est.	Stourbridge fire-clay.
(*d.*)	Germany(?) . .	47.500	34.370	1.240	.500	1.000	not est	not est.	not est.	not est.	1.000	Crucible clay, of Almerode.
1443	Illinois	70.660	20.309		*.960	.307	.051	1.188	.819	.487	5.219	Post Tertiary clay, foot of Grand Chain.
1477	Greenup . . .	49.680	35.281	traces.	.213	.136	.626	not est.	.193	.211	13.660	Fire-clay, Kenton Furnace, Louder's land.
1478	Greenup . . .	62.920	20.735	3.820	.213	2.281	.371	not est.	2.641	.659	6.400	Fire-clay, Kenton Furnace, Powder-mill Hollow.
1479	Greenup . . .	66.560	22.679	traces.	.157	.605	.563	not est.	1.946	.603	6.800	Clay, Pea Ridge.
1480	Greenup. . . .	47.060	36.620	traces.	.615	.389	.626	not est.	1.176	.234	13.330	Clay, Pea Ridge, near Hunnewell.
1481	Greenup. . . .	67.700	22.092	traces.	.101	.285	.498	not est.	1.136	.268	7.900	Clay, Pea Ridge, two and a half feet bed.
1482	Greenup. . . .	55.560	31.027	traces.	.325	.403	.358	not est.	1.167	.560	10.600	Clay, Pea Ridge, fourteen inch, third bed.
1483	Greenup. . . .	47.560	40.661	a trace.	.280	.497	.249	a trace.	.308	.409	10.036	Fire-clay, Thomas' bank, Shultz's Creek.
1613	Muhlenburg . .	63.180	26.281		.203	.255	.179	3.282	2.000	.425	4.195	Ross' coal mines, fire-clay, below the coal.

*Carbonate.

TABLE VI. PIG IRONS.

Number in Report.	County.	Specific gravity.	Iron.	Graphite.	Combined carbon.	Manganese.	Silicon.	Slag.	Aluminum.	Calcium.	Magnesium.	Potassium.	Sodium.	Phosphorus.	Sulphur.	Total carbon.	Remarks.
1293	Boyd	7.132	93.208	3.350	.220	.054	2.389	1.160	.193	.144	.095	.047	.032	.194	.005	3.570	Hot blast, No. 1, Bellefont Furnace.
1294	Boyd . . .	7.127	93.712	2.990	.210	.056	1.908	.600	.644	.104	.095	.063	.010	.380	.066	3.200	Hot blast, No. 1, Buena Vista Furnace.
1295	Boyd	6.410	91.429	2.460	.240	.195	3.709	.540	not est	.176	.233	not est	not est	.385	.082	2.700	Stone-coal, No. 1 mill, Ashland Furnace.
1296	Boyd	6.503	90.899	2.560	.160	.236	5.121	.760	not est	.072	.100	not est	not est	.394	.045	2.720	Stone-coal, No. 2 mill, Ashland Furnace.
1297	Boyd	6.406	89.731	1.660	.790	.471	6.308	1.120	not est	.152	.060	not est	not est	.461	.015	2.450	Stone-coal, foundry iron, Ashland Furnace.
1391	Carter.	6.423	90.958	2.104	.116	.115	2.682	4.180	.479	not est	not est	not est	not est	.304	not est	2.280	Foundry iron, No. 2, Boone Furnace.
1392	Carter.	6.905	93.212	2.940	.060	.083	1.634	2.460	.330	not est	not est	not est	not est	.486	.079	3.000	Foundry iron, No. 1, Boone Furnace.
1393	Carter.	7.021	92.387	3.340	.760	.056	2.240	.620	.120	.120	.056	.080	. . .	.836	.057	4.100	Hot blast, No. 1, Iron Hills Furnace.
1394	Carter.	6.889	91.502	2.670	.030	.123	4.470	1.160	.128	.144	.112	.076	.023	.203	.041	2.700	Hot blast, No. 1, Mt. Savage Furnace.
1531	Greenup. . . .	6.825	91.656	2.790	a trace	.084	4.106	.630	.399	.168	.095	.086	.016	.695	.150	2.790	Hot blast, No. 1, Buffalo Furnace.
1532	Greenup. . . .	6.941	94.739	3.620	.780	.056	.877	.120	.060	.104	.082	.048	.041	.609	.037	4.400	Cold blast, No. 1, Buffalo Furnace.
1533	Greenup. . . .	6.872	88.106	1.950	.570	.014	7.317	.900	.165	.128	.125	.048	.002	not est	.019	2.520	Hot blast, silver-grey, Buffalo Furnace.
1534	Greenup. . . .	6.897	92.724	3.320	.660	.612	2.090	.300	.442	.184	.190	.104	.004	.622	.046	3 980	Hot blast, No. 1 foundry, Kenton Furnace.
1535	Greenup. . . .	7.117	91.668	2.950	. . .	.332	3.817	1.200	.128	.075	.122	not est	not est	.334	.041	2.950	Hot blast, No. 1, Raccoon Furnace.
1536	Greenup. . . .	7.041	92.368	3.690	. . .	.020	2.515	1.130	.582	.048	a trace	.056	a trace	.684	.026	3.690	Hot blast, No. 2, Hunnewell Furnace.
1614	Muhlenburg . .	6.826	86.636	.900	2.080	.202	7.704	2.260	.123	.045	.035	not est	not est	.235	.104	2.980	Silver-grey, Airdrie Furnace.
1615	Muhlenburg . .	6.826	85.455	.480	1.560	.696	7.747	3.460	.098	.089	.017	not est	not est	.445	.122	2.040	Silver-grey, Airdrie Furnace.
1616	Muhlenburg . .	7.782	86.842	.740	1.460	.355	8.614	2.360	.054	.112	.056	not est	not est	.123	.122	2.200	Silver-grey, Airdrie Furnace.
1643	Edmonson. . .	7.113	94.287	3.100	.700	not est	.493	not est	not est	not est	not est	not est	not est	1.029	.012	3.800	Cold blast, old Nolin Furnace.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

CHEMICAL REPORT

OF THE

SOILS, COALS, ORES, IRON FURNACE PRODUCTS, CLAYS, MARLS, MINERAL WATERS, ROCKS, &C.,

OF KENTUCKY,

BY ROBERT PETER, M. D., ETC., ETC.,

CHEMIST TO THE KENTUCKY GEOLOGICAL SURVEY.

ASSISTED BY

JOHN H. TALBUTT, S. B., CHEMICAL ASSISTANT.

SECOND CHEMICAL REPORT IN THE NEW SERIES AND THE SIXTH SINCE THE BEGINNING OF THE SURVEY.

INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE
KENTUCKY STATE GEOLOGICAL SURVEY,
LEXINGTON, February, 1877.

Professor N. S. SHALER, *Chief Geologist, &c.:*

DEAR SIR: I have the pleasure to report the results of the chemical work performed by myself and Mr. Talbutt, for the State Geological Survey, during the past year, or since the preparation of the last report nearly up to the present date.

Very respectfully,

ROBERT PETER.

CHEMICAL REPORT OF THE SOILS, COALS, ORES, IRON FURNACE PRODUCTS, CLAYS, MARLS, MINERAL WATERS, ROCKS, &c., OF KENTUCKY, BY ROBERT PETER, M. D., ETC.

The chemical analyses of eighty-three *soils*, from twelve counties of the State, are given in the following detailed report. The limits of the variations of their several essential ingredients are shown in the following table, viz:

	Pr. cent.	No.	County.	Per cent.	No.	County.
Organic and volatile matters vary from	11.565	in 1684	in Bell	to 1.052	in 1903	in Muhlenb'rg.
Alumina and iron and manganese oxides vary from	19.921	in 1783	in Fayette	to 2.815	in 1692	in Bell.
Lime carbonate varies from	1.145	in 1781	in Fayette	a trace.	in 1871	in Lewis.
Magnesia varies from	.394	in 1781	in Fayette	to .011	in 1853	in Laurel.
Phosphoric acid varies from	.540	in 1780	in Fayette	to .061	in several.	
Potash varies from	.755	in 1783	in Fayette	to .068	in 1684	in Bell.
Soda varies from	.477	in 1903	in Muhlenburg	to traces	in several.	
Sand and insoluble silicates vary from	72.540	in 1783	in Fayette	to 95.115	in 1683	in Bell.
Water expelled at 380° F. varies from	2.515	in 1696	in Bell	to .035	in 1684	in Bell.
Water expelled at 212° F. varies from	3 525	in 1783	in Fayette	to .435	in 1852	in Knox.
Potash in the insoluble silicates varies from	2.640	in 1696	in Bell	to .399	in 1852	in Knox.
Soda in the insoluble silicates varies from	1.044	in 1728	in Christian to	traces in	several.	

This table of extremes of composition shows wider limits than that of volume I, and may be supposed to exhibit the relative chemical composition of very good and very poor soils. The rich soil being characterized by larger proportions of organic and volatile matters (within certain limits), causing the soil to absorb and retain much hygroscopic moisture (expelled at 212° F.); larger relative quantities of alumina, &c., &c., which hold more water, &c., expelled at 380° F.; but especially being more rich in the available alkalies, potash and soda (particularly potash); by containing more phosphoric acid, lime, &c., and having less sand and insoluble silicates. The poor soil generally contains a larger quantity of sand and insoluble silicates and smaller proportions of the other named ingredients. Exceptions occur to these general statements, of course; for great excess of lime or magnesia carbonates,

of organic matters, or of clay, may make a poor soil; or, on the other hand, the absence of any single essential element in it may render unavailable normal proportions of all the others. The study of the soil in relation to its productiveness presents, indeed, a complex problem; many conditions, both physical and chemical, enter into it, all equally important. Even the relative state of division, whether fine or coarse, of two soils otherwise presenting similar chemical, physical, and atmospheric conditions, is found greatly to influence its fertility.

Another varying condition is the influence of water upon the soil, which, in the valley, may bring fertilizing ingredients to the soil from the higher grounds by deposit of suspended mud left by the overflowing fluid, or may carry dissolved elements of plant food into its interior by gradual infiltration. On the other hand the flood, on the higher slopes, not only carries off to the lower levels the richer and finer solid materials, but, by a continued leaching process, may actually dissolve and remove the alkalies, lime, magnesia, phosphates, and organic matters, and even gradually decompose the insoluble silicates and carry off the store of alkalies naturally contained in some of them. The examination of some of the soils of the mountain region seemed to show that underground drainage, through a measurably open subsoil, had thus acted on the silicates contained in them.

In many cases the subsoil in the samples examined was richer in the mineral elements of fertility than the surface soil, and in some few cases it seemed to have had a different origin. The influence of the subsoil, when more or less mixed with the upper soil in the processes of cultivation, was measurably observable in studying the gradual exhaustion produced by cropping. In some cases seemingly making the soil of the old field fully as rich as the virgin soil, supposing both originally to have been similar in composition, which is not always true. The comparison of the old cultivated soil with the virgin soil of the immediate vicinity does not, therefore, in all cases, show an apparent reduction of the elements of fertility in the former; yet, the fact is demonstrated, in a large propor-

tion of cases, where the soil is uniform in the region and care has been taken in the selection of the samples. Superficial impurities, which might greatly interfere with the results, are easily to be avoided in the collection of the soils in most cases.

But the subsoil, although quite rich in potash, soda, phosphates, and other mineral fertilizers, does not always improve the immediate fertility of the soil when brought up to the surface in too large quantity at one time. Indeed gardeners find, generally, that it reduces the fertility of the surface unless it is liberally mixed with organic manures. Hence, while they may loosen the earth to a considerable depth, by a process of *subsoiling*, to favor drainage, the penetration of the atmospheric gases and the free spreading of the roots of their vegetables, they are generally careful not to *trench* the soil so as to throw much of the heavy subsoil upon the surface. Of course subsoils vary in composition; but the subsoils of this region are usually quite rich in potash, soda, and phosphates, held in firm combination, however, in the silicates which are insoluble in the ordinary acids; they contain more of the materials of clay—alumina, iron oxide, &c.—than the surface soil generally, and but a small quantity of organic and volatile matters.

As the organic compounds of the soil are greatly instrumental in bringing the mineral elements of plant food into a soluble or available condition, and as they even act on the insoluble silicates, to set free and make soluble their constituent alkalies and phosphates, &c., the measurable absence of the organic matters from the heavy subsoil may have much to do with its inertness as compared with its chemical composition.

The extensive study which has been made in this laboratory of the insoluble silicates of our soils, during the past year, has thrown much light on this subject, as well as on the probable origin of some of our soils. All of the soils examined were found to have a notable quantity of alkalies in the silicious residue left after a ten,or twelve days' digestion in chlorohydric acid of the density of 1.1, and, as may be seen by refer-

ence to the table of extremes of composition given above, this quantity varies from 2.640 per cent. of potash down to 0.399 per cent., which was the smallest proportion found in any, and which, as is universally the case, is much greater than the amount removed from the soil by the action of chlorohydric or nitric acid.

The silicious residue of our Kentucky soils, left after prolonged digestion in the acids, is generally in such a fine state of division that all or most of it will readily pass through fine bolting-cloth. Hence our best Kentucky soil has been popularly said to have no sand in it. Indeed, in the "Blue Grass Region," so-called—the most fertile part of the State—sand is so scarce that it usually must be hauled from the river beds at some distance, and its cost to the builder is quite considerable. But a large proportion of the very fine silicious residue of our soils is really very fine quartzose sand, some grains being clear and colorless, some milky or colored, and only a few, of the same character, separable by the bolting-cloth from some of the soils, are of a somewhat larger size, indicating the fact that our soils, or the rocks from the disintegration of which they are derived, have been deposited under comparatively quiet waters, possibly of a deep sea at a distance from its shores.

But, mixed with the purely silicious grains is quite a considerable quantity of grains of *silicates*, containing the alkalies in considerable proportions, doubtless of the nature of the felspar and mica of the granitic rocks and other minerals analogous in chemical composition, holding in reserve a great treasure of these important elements of organic nourishment, the alkalies.

When we consider the wide diffusion of these finely divided silicates—for it is probable they enter into the constitution of all the soils of the world—we may well be astonished at the vast extent of rock disintegration which was necessary to their production, and admire this wonderful provision for maintaining the productiveness of the soil.

As regards the proportion of *phosphates* contained in these insoluble silicates, it is the design of the writer to institute an investigation, as occasion may favor, during the progress of the Survey.

It has been conclusively established that *mineral* fertilizers alone will not suffice to render soil productive. The greater proportion of vegetable and animal bodies is made up of the so-called *atmospheric elements*, viz: carbon, hydrogen, oxygen, and nitrogen; and the latter element, although entering into their composition in much smaller proportions than the other three, has most attracted the attention of vegetable physiologists and agriculturalists; mainly for the reason, that while the carbon is readily appropriated by the plant, in the decomposition of carbonic acid under the influence of the sun's light—this acid being never absent from the soil or the atmosphere—and water, always present, yields the necessary hydrogen and oxygen, nitrogen cannot, as a general rule, with some exceptions, be directly assimilated from the atmospheric gases by the growing vegetable. With the exception of plants of the clover or pea family, and a few others, all growing vegetables must be supplied with this essential element, nitrogen, in some form of compound, they not seeming generally to be endowed with the force requisite to coerce into the liquid or solid state this gas, which has withstood all the efforts of man, by the use of immense pressure and intense cold, to condense it even into the liquid form.

Under ordinary circumstances of natural vegetable growth, nitrogen is presented to the plant, sometimes in the form of ammonia (composed of nitrogen and hydrogen), or of some of its compounds, resulting from the decomposition of animal bodies and products; sometimes in that of nitrates or analogous compounds, which originate in the union of nitrogen and oxygen and some base; all of which nitrogenous compounds are easily soluble in water, and thus readily enter the vegetable tissues. But the ordinary natural supply of these compounds is limited, and hence, when the soil is to be stimulated to its highest degree of productiveness, and its fertility made

continuous, the cultivator necessarily resorts to the admixture of nitrogenous compounds of some sort with his fertilizers. The nitrogenous organic compounds of both animals and plants are always associated with phosphates; and it is believed, that while potash is absolutely necessary in the growing vegetable for the production and transfer of its non-nitrogenous constituents, nitrogenous compounds and phosphates are also mutually dependent—all being equally indispensable. So that the agricultural chemists of the Liebig school, who contend for the exclusive importance of the mineral elements of fertility, and those of the French and English schools, who see no value in manures outside of the nitrogen compounds, are equally too exclusive, and equally in fault.

These questions have long been of vital interest in the older and more thickly populated countries, while in our comparatively new continent the virgin soil still bountifully responds to the labor of the farmer without the aid of artificial fertilizers, and with but little evidence of exhaustion. But here, as everywhere, except where the soil is continually renewed by exceptional and local causes, such as the existence of an unusually rich and readily decomposable sub-stratum, or the periodical fertilizing overflow of rivers, the continued demands of the farmer upon the land inevitably reduces its productiveness—an effect which is increased as population enlarges. And it is even now the fact that, over a large portion of our State and country, profitable farming without the aid of manures is practically at an end. The future of our husbandry will be mainly the application of fertilizers to the soil, as a vehicle of production, by the aid of capital, skill, and industry; which will be the more profitable as the population becomes more dense, and the home market is enlarged by the increase amongst us of other industrial occupations, more especially of the manufactures.

Kentucky is eminently endowed by nature for the support of extensive and most important manufactures. Her immense natural resources in coal, iron ores, clays, limestones, salt, &c., &c.—materials which are essential to almost all the

arts of civilization, and give employment to more individuals than any other natural products, those of the field, perhaps, excepted—only await development to make her one of the most powerful Commonwealths of the world. The great wealth and power of Great Britain rest on her coal and iron fields mainly.

During the past year, proximate analyses have been made, in this laboratory, of one hundred and forty-seven several samples of *Kentucky coals*, in addition to those reported in previous volumes of the reports. As might have been expected, these exhibit a considerable variety in their composition, as may be seen by examining the table at the end of this chemical report.

The general average of ash and sulphur in the coals examined this year doubtless falls somewhat below that of the samples examined in the previous year; but, as might be expected, very great differences are to be observed among them. Thus the limits of the ash per centage extend from 2.60 per cent., in Nos. 1908 and 1810, from Ohio county, to 34.72 per cent., in No. 1914, from Ohio county.

The great proportion of the ash of No. 1914 is exceptional, however, and although this coal is called a cannel coal by some, it doubtless should be denominated a bituminous shale. Indeed, where the earthy matters exceed twenty per cent. of the material, the name coal is not as appropriate as the latter term, although the mineral may yet be made quite useful for fuel, or possibly for distillation, in the vicinity of its bed.

The limits of total sulphur in these coals examined this year are from 0.530 per cent., in the cannel coal, No. 1966, from Wolfe county, to 7.959 per cent., in No. 1923, from Ohio county.

A remarkable fact in relation to this latter coal is, that while the sulphur per centage is nearly eight the ash per centage is only a little above twelve, indicating that much of this combustible substance is either in the free state or in some form of organic compound in the coal. Other coals, with a large quantity of sulphur, show the same fact, and the inference is that a considerable proportion of this sulphur may be removed

in the operation of coking the coal. Remarks on the probable condition of sulphur in coals, and on its removal, will be found in the succeeding detailed report, especially under the head of Bell county.

As was remarked in the previous volume, the coals of the eastern coal field appear to be somewhat less sulphurous, in the average, than those of the western. Recent imperfect investigations into those parts of the eastern coal field which are yet measurably unexplored, and which are beyond the usual channels of communication, have shown the existence there of coals of great value and remarkable purity, some of which, like the celebrated Indiana "Block coal," may be used in the smelting of the abundant iron ore without the preliminary process of coking.

Under the heads of Bell and Breathitt counties, the general correspondence between the specific gravity and the ash per centage was again exhibited; and it is to be noted, that while the density of the coal, as a general rule, increases with the ash per centage, the cannel coals offer a marked exception, or exhibit a ratio of their own. What the ratio is, in the different sorts of coal, cannot well be made out at present, especially because the different varieties shade into each other, and difference of age and the action of physical agencies may affect the relative density, independent of the earthy matters, as well as the various kinds of organic materials from which the coals were derived.

To illustrate more fully this correspondence between specific gravity and ash per centage, another table, viz: that of the coals from Ohio county, is appended, as follows:

Number.	Specific gravity.	Ash per centage.	Number.	Specific gravity.	Ash per centage.
1910	1.251	2.60	1907	1.336	10.30
1915	1.273	4.00	1919	1.340	8.30
1926	1.282	3.16	1927	1.348	7.72
1908	1.295	2.60	1913	1.345	9.28
1917	1.295	5.00	1920	1.356	9.94
1909	1.297	3.40	1921	1.357	8.14
1916	1.305	4.00	1922	1.380	9.34
1924	1.310	5.94	1911	1.382	9.96
1925	1.310	9.92	1918	1.384	14.20
1906	1.310	7.46	1912	1.386	9.24
1904	1.318	7.54	1929	1.411	12.50
1928	1.321	4.36	1923	1.413	12.10
1905	1.331	8.44	1914*	1.593	34.72

*A bituminous shale or impure cannel coal.

It is believed, that notwithstanding the large proportions of ash and sulphur in some of these samples of coals analyzed, the general, or average quality of the coals of the very extensive coal fields of Kentucky will compare favorably with that of the coals of any other region.

Only about twenty-four *iron ores*, of the limonite variety, and five clay iron-stones have been analyzed since the last report. These are from seven counties only, and are found to vary in their proportions of *iron* between the extremes of twenty-three and more than fifty-three per cent. of that metal. Their proportions of *phosphorus* vary from 1.60 to 0.065 per cent., the largest proportion of this injurious element having been found in the "Clinton ore," of Old Slate Furnace, of Bath county.

As is pretty well established, phosphorus is more injurious to the quality of the iron than any other ingredient of the ore, especially in causing it to be "cold-short," or, in other words, diminishing its tenacity or toughness. Silicon, in certain proportions, is also injurious in this respect; but the presence of phosphorus in the ore is more to be deprecated, because it is to be removed with more difficulty from the iron in the subsequent refining processes; silicon being easily oxidated, or burnt out with the excess of carbon and some other impurities of the pig metal, in the puddling or even in

the Bessemer process, while phosphorus is believed to maintain more obstinately its union with the metallic iron.

The general belief was, even among modern scientific observers, that all the phosphoric acid in the iron ore, or in the flux material and fuel, used in the ordinary smelting furnace, finds its way into the reduced metal, pig iron, produced, and is held in it, in firm combination, in the form of iron phosphide. Hence, it was claimed, a phosphatic ore necessarily produces a yet more phosphatic iron, because the phosphorus, all of which is supposed to combine with the metal, is, of course, in larger proportion to the iron than to the ore, &c.

But analyses, made by the writer, of samples of iron furnace cinder or slag, published in the volumes of the first series of reports of the Kentucky Geological Survey, as well as in the present report (see Greenup county), show the presence of notable quantities of phosphoric acid in this slag, and thus lead to the conclusion that it is possible, by a proper management of the furnace and of the fluxes used, to eliminate, in this form, a considerable proportion of this injurious ingredient in the smelting of the ore. If the phosphatic iron ore, in the high furnace, be subjected to a very intense heat, in presence of the reducing gases, the phosphoric acid will be reduced to phosphorus, which will unite with the reduced iron when it melts, provided a proper basic flux material be not present to fuse with the phosphoric acid before it is deoxidated, and thus protect it from reduction. But, in the presence of such a basic flux material, it is probable that the iron of the ore, if it be reduced at a more moderate heat, and while yet unmelted, may afterwards melt at a heat not quite high enough to reduce the phosphoric acid, which then would go off in the slag.

The strong affinity which exists between alumina and phosphoric acid justifies the belief that this material, in the flux or in the ore, may be especially useful in this process of purification in the smelting furnace; when used in combination with a sufficiency of lime or other fluxing materials to make a rather fusible basic flux, and with not too high a temperature

in the reducing part of the furnace. It is well known that alumina is an essential ingredient of all clays.

It has long been known that the phosphorus of the impure iron may be removed, in great measure, by the aid of oxygen and fluxing materials; and this fact has long been practically applied in the various refining processes, in which the melted pig metal is exposed to the oxygen of the air, or to that which is separated from powdered iron or manganese oxides, or derived from common nitre or nitrate of soda. The oxygen burns out or oxidates the phosphorus (together with the other oxidable ingredients—carbon, silicon, sulphur, &c.), and the phosphoric acid which is formed unites generally with iron or manganese oxides, as phosphates, in the melted cinder. This is the theory of all the various refining processes, including that called puddling and the Bessemer process, which latter process, however, because, probably, of the want of a fluid basic flux to dissolve compounds of phosphoric acid, is not effectual in the removal of phosphorus.

Amongst the modern processes for iron purification is the patent one of Henderson, originated in England, but which seems to have been employed in this country, at the Hamburg Iron Works, Hamburg, Pennsylvania. An English pamphlet, obtained by the writer at the Centennial Exhibition, gives many interesting facts in relation to it and its results. The refining process is, to pour the melted impure pig metal on a mixture of powdered fluor-spar and titanic iron ore (ilmenite), or peroxide of manganese, &c., placed on the floor of the ordinary puddling furnace; "the furnace door being then closed, the powdered mixture fuses, and the iron is allowed to boil for about half an hour; the rabble is then worked for about ten minutes, and the metal is balled up in the usual way. The whole time occupied by one charge, with ordinary grey forge pig iron, being a little under an hour."

It is claimed, that in this time the commonest and most impure pig iron may have most of its phosphorus, sulphur, silicon, and carbon removed; and that it may be brought to a state of purity, toughness, and ductility equal to that of the

best Swedish iron. In this pamphlet this claim is corroborated by numerous chemical analyses of the pig metal and of the purified wrought iron, by Dr. Henry M. Noad, F. R. S.; Mr. Edward Riley, F. C. S.; and Mr. W. Matthiew Williams, F. C. S., as well as by many mechanical tests of the metal by Mr. David Kirkaldy.

The chemical analysis of the *slag* produced in this process throws a little light upon the theory of the depurative action of the re-agents used. (See table 19 of the pamphlet.) Some of this slag, analyzed by Mr. Edward Riley, F. C. S., gave the following results:

Silica	11.12	
Titanic acid	5.02	
Protoxide of iron	56.41	= 58.0 per cent. of *iron*.
Peroxide of iron	18.20	
Alumina	1.73	
Manganese	2.22	
Phosphoric acid	1.19	= .47 per cent. of *phosphorus*.
Sulphur	.09	
Lime	3.51	
	99.49	

The author of the process asserts that most of the phosphorus goes off in the form of vapor; but it is evident that it mostly separates in the slag, after having formed phosphoric acid by union with oxygen. No doubt the manganese oxide aided in the oxidation of the carbon, sulphur, and phosphorus of the pig iron, and the fluorine of the fluor-spar may have combined with the silicon to produce a volatile fluoride of silicon; for we see no statement of any fluorine in the analysis of the slag; but it is believed, that in the ordinary operation of puddling, the atmospheric oxygen, or that derived from a lining of powdered iron ore, &c., may remove all these, if it be carefully performed, more especially if materials be brought in contact with the boiling iron, which may readily melt into a sufficient basic cinder to carry off the fixed impurities, including phosphates which may result from the oxidation of the phosphorus of the iron. That the fluor-spar may both serve to form the flux and quicken the separation of the silicon and phosphorus, was fully established by Carron.

A large quantity of iron oxides appears in this cinder, in the above statement of the analysis, equivalent to fifty-eight per cent. of the whole slag. But it is probable that most of this was derived from the powdered ilmenite (titanic iron oxide) used in the process. In the ordinary puddling slag the large proportion of iron oxide always present is derived from the pig iron. It is very probable that the mixture of the powdered iron ore with the fluor-spar may lessen the loss of metal in the puddling. According to the published statement, the loss in purifying the most common pig iron into fine wrought iron, by the Henderson process, is only ten per cent.

It is generally believed that, in the ordinary refining processes, the agent which is especially effectual in the removal of the phosphorus is the tri-basic silicate of iron, which forms a fluid cinder or slag, and which is produced by the oxidation of the ingredients of the pig metal at a great expense of iron. There can be no doubt that this loss may be measurably prevented, and the purification facilitated, by the use of a "lining" of powdered oxide of iron (iron ore), with some compound of lime (fluor-spar or limestone), to give oxygen and form a fluid basic flux to carry off the phosphoric and silicic acids, &c. Whether the use of similar materials, to furnish oxygen and the ingredients for a somewhat basic flux to carry off phosphoric acid, is possible in the Bessemer process, is well worthy of trial. Fluor-spar commends itself because of its ready fusibility and its power of fluxing earthy materials generally, so that it possibly may dissolve, retain, and protect from reduction the oxidated phosphatic compounds, at a temperature sufficient to melt iron, and thus aid in their removal. The presence of alumina in the cinder seems also to be beneficial in this respect.

Not the least interesting of the iron ores analyzed, during the past year, are those described in the Appendix as Clinton iron ore, dyestone ore, or fossil ore, from very extensive beds in the mountainous region of Tennessee, near the Kentucky State line, in the Cumberland Gap region, which, because of

their abundance in the vicinity of our coal beds, their general richness in iron (one sample giving more than fifty-six per cent. of this metal, on analysis), as well as because of their unexpected moderate proportion of phosphorus, in this locality, promise to become of great industrial value.

Some of the iron smelted from this Clinton ore, at the Old Clinton Furnace, at Cumberland Gap, the analysis of which is also given in the Appendix, corroborates this expectation.

The twenty-two samples of pig iron analyzed, from five counties of the State, vary in their specific gravity from 6.163 to 7.435; in their per centage of *iron*, from 89.687 to 94.764; in their per centage of *total carbon*, from 2.800 to 4.720; in that of *phosphorus*, from 1.080 to 0.120; in that of *silicon*, from 5.082 to 0.363, and in that of *sulphur*, from 0.278 to 0.011. This includes samples of hot-blast stone-coal iron, as well as cold-blast charcoal iron. From these and the analyses previously made, it is evident that iron of almost any desirable quality can be manufactured in our State from her natural products, which are unusually abundant, and await only the judicious application of capital, skill, and labor to give to her great prominence as a manufacturing State.

An interesting discovery of a phosphatic layer in the blue limestone (Lower Silurian) is recorded under the head of Fayette county; and some suggestions as to the use of the Bittern water of our salt works, and other means in rendering more available for fertilizers the beds of marls of our State, will be found under the heads of Clay and Grayson counties.

Another interesting fact reported is the existence of barium and strontium chlorides in the brines of Clay and Meade counties.

BATH COUNTY.

Limonite iron ores, labeled as follows:

No. 1652—LIMONITE, *from Slate Furnace ore banks, "Howard's Hill;" Upper Silurian formation. Collected by P. N. Moore.*

In porous, or fine cellular, irregular, thin laminæ; oölitic in parts; of a dark-brown color, with ochreous incrusting material.

No. 1653—LIMONITE, *from Slate Furnace ore bank. Upper part of the bed. Collected by P. N. Moore.*

Mostly of a yellowish-brown color, and somewhat friable, with some darker-brown and denser irregular laminæ. The whole presenting a fine-grained oölitic appearance, from the presence of small spherical cavities, more or less incrusted with whitish and yellowish material.

No. 1654—LIMONITE ORE *at the Chalybeate Springs, Pilot Knob. Collected by P. N. Moore.*

In thin irregular laminæ, of a dark reddish-brown color, with some bright red and yellowish ochreous material.

No. 1655—LIMONITE (*with carbonate*), *said to be eighteen to twenty feet thick, from near Owingsville, on the road to Slate Creek. Collected by P. N. Moore.*

Of a fine oölitic structure. Colors varying from yellowish and reddish-brown to greyish-brown, with greenish-grey infiltration in some parts.

No. 1656—LIMONITE, *from "Old Coaling Bank," head of Clear Creek; in Sub-carboniferous limestone. Average sample collected by P. N. Moore.*

Principally of a dark reddish-brown color, with some little of lighter color.

No. 1657—LIMONITE, *from the "Richardson Bank," Clear Creek; in Sub-carboniferous limestone. Average sample collected by P. N. Moore.*

A dense ore, generally of a dark brown color, with a small proportion of greyish.

No. 1658—LIMONITE, *from the "Pergam Bank," Clear Creek; in Sub-carboniferous limestone. Average sample collected by P. N. Moore.*

A dense ore, generally of a dark brown color, with some little ochreous.

COMPOSITION OF THESE BATH COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1652	No. 1653	No. 1654	No. 1655	No. 1656	No. 1657	No. 1658
Iron peroxide	70.060	69.728	47.321	39.068	59.621	66.329	65.310
Iron carbonate				11.479			
Alumina	4.540	8.642	5.418	8.346	12.370	12.532	11.947
Manganese peroxide	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Lime carbonate	.040	.170	.690	18.710	.500	a trace.	.730
Magnesia	.021	.045	.079	6.159	.144	.173	.140
Phosphoric acid	1.620	1.154	.161	.868	.709	.709	.825
Sulphuric acid	.031	.134	.376	.185	a trace.	a trace.	a trace.
Combined water	12.300	12.650	12.050	7.835	10.400	9.580	11.000
Silicious residue	11.530	7.930	33.330	7.350	15.830	9.720	9.580
Total	100.142	100.453	99.425	100.000	99.574	99.043	99.532
Iron, per cent.	49.042	48.809	33.125	30.734	41.735	46.440	44.570
Phosphorus, per cent.	0.707	.504	.070	.379	.309	.309	.360
Sulphur, per cent.	.012	.053	.150	.074	a trace.	a trace.	a trace.
Silica, per cent.	11.530	7.760	27.600	7.560	13.960	9.060	9.580
Specific gravity	3.470	3.405	not est.	not est.	not est.	not est.	not est.

All of these ores are sufficiently rich for profitable smelting. Nos. 1652, 1653, and 1657 are more than usually rich in iron. The first two contain more phosphorus than is desirable, but much of this may be removed in the slag, if there be much alumina present; moreover, it would not be seriously objectionable in ordinary castings. No. 1655, containing quite large proportions of lime and magnesia, might profitably be mixed with more silicious and richer ores for smelting. Sulphur is not superabundant, except in No. 1654.

PIG IRON FROM BATH COUNTY.

No. 1659—LABELED "*No. 1 Cold-blast Charcoal Iron; Bath Furnace. Collected by P. N. Moore.*"

A dark-colored, moderately coarse-grained iron. Yields readily to the file; flattens considerably under the hammer.

No. 1660—"*Pig Iron from Old Slate Furnace.*" *Collected by P. N. Moore.*

Finer-grained, harder, and less tough than the preceding, but yields to the file and extends somewhat under the hammer.

No. 1661 — LABELED "*No.* 1 *Cold-blast Charcoal Car-wheel Iron,*" *from Cottage Furnace. Sent by G. S. Moore & Co., of Louisville.*

Moderately coarse-grained; somewhat dark grey. Yields with difficulty to the file; extends somewhat under the hammer.

No. 1662—"*No.* 2 *Cold-blast Charcoal Pig Iron,*" *from Bath Furnace. Collected by P. N. Moore.*

A moderately fine-grained grey iron. Yields to the file; extends considerably under the hammer.

No. 1663—"*No.* 3 *Cold-blast Charcoal Pig Iron,*" *from Bath Furnace. Collected by P. N. Moore.*

Finer-grained than the preceding. Yields to the file; extends rather more under the hammer than the preceding.

No. 1664—"*No.* 4 *Cold-blast Charcoal Pig Iron, from Bath Furnace. Collected by P. N. Moore.*"

Finer-grained than the preceding. Quite fine-grained, and dark grey. Yields to the file; extends somewhat under the hammer.

COMPOSITION OF THESE BATH COUNTY PIG IRONS.

	No. 1659.	No. 1660.	No. 1661.	No. 1662.	No. 1663.	No. 1664.
Iron	92.631	92.056	93.106	91.924	93.472	93.004
Graphite	3.840	3.640	3.860	3.440	3.100	2.700
Combined carbon	.710	.310	.590	1.060	1.510	1.410
Silicon	1.520	1.760	.914	1.319	.652	1.007
Slag	.100	.100	.160	.260	.160	.260
Calcium	.090	.116	not est.	not est.	not est.	not est.
Phosphorus	.363	1.080	.527	.220	.290	.262
Sulphur	.278	.218	.011	.107	.121	.172
Total	99.532	99.280	99.168	98.330	99.305	98.815
Total carbon	4.550	3.950	4.450	4.500	4.610	4.110
Specific gravity	7.070	7.067	7.142	7.017	7.092	7.168

The pig iron of the Bath Furnace has a well deserved reputation for yielding iron of great tenacity, and hence is preferred for railroad axles. Its small proportion of phosphorus* does not seem to injure it in this respect. It, as well as the other specimens from Bath county, contains more than the usual proportion of carbon. The iron of the Old Slate Furnace, prepared from the phosphatic ores of the Upper Silurian Group, contains more phosphorus than is desirable in the manufacture of tough bar iron or steel. This impurity does not prevent it from being available in almost all ordinary castings.

BARREN COUNTY.

No. 1665—"*Marly Deposit in Proctor's Cave. In the cavernous Sub-carboniferous limestone, Barren county.*" *Said to be good for polishing metals.*

The dried lumps are very fine-grained, and are light-grey, nearly white. Adhere to the tongue.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	66.160
Magnesia carbonate	14.083
Alumina and iron and manganese oxides, and phosphoric acid	5.800
Water, alkalies, and loss	5.097
Silica and insoluble silicates	8.860
Total	100.000

If in sufficient quantity, it might not only be useful for polishing the soft metals, but might be used as a fertilizer, or, very probably, it would make a hydraulic cement, if properly calcined.

No. 1666—"NITRE EARTH. *From Grand Avenue Cave, three miles northwest of Glasgow Junction, Barren county. Collected by Prof. N. S. Shaler.*"

A light cinnamon-colored earth, containing excrements of bats, &c., &c.

*It is believed by the writer that, in consequence of the difficulties attending the estimation of the phosphorus in iron, this ingredient has been often under-estimated by chemists, and, consequently, its evil influence has been over-estimated.

Qualitatively examined, it was found to contain ammonia salt, or some nitrogenous matter which yields this alkali under the action of lime; also much lime sulphate.

Quantitative analysis showed, however, that it only contained of nitric acid 0.0025 per cent.; of potash, .0129 per cent.; of soda, .0024; so that it would not prove valuable as a source of nitre, although, if in sufficient quantity, it might be useful as a fertilizer.

BELL COUNTY.

COALS OF BELL COUNTY.

No. 1667—"*Coal, from Abraham Lock's coal bank, Straight Creek, Bell county. Collected by A. R. Crandall.*"

A somewhat soft, pure-looking splint coal. Very little fibrous coal and no pyrites apparent. Some ferruginous stain in the seams.

No. 1668—"*Cannel Coal, from Col. John G. Eve's land, Fork Ridge, near Stony Creek. Fourteen inches thick. Taken from the bed of Mountain Creek. It is probably better beyond the opening.*"

Tough; fracture somewhat conchoidal; lustre satiny. No appearance of pyrites. Some ferruginous stain on the surface.

No. 1669—"*Hignite Coal, from Hignite Branch of Yellow Creek. Upper bed. Collected by A. R. Crandall.*"

A splint coal, with very little fibrous coal or granular pyrites between the laminæ.

No. 1670—"*Coal, from the same locality as the last sample. Middle bed. Collected by A. R. Crandall.*"

Does not differ much in appearance from the preceding.

No. 1671—"*Coal, from the same locality. Lower bed. Collected by A. R. Crandall.*"

No. 1672—"*Coal, from Little Clear Creek. In the shales above the Conglomerate. Bed two feet thick; fifteen feet above the creek. Collected by A. R. Crandall.*"

A semi-cannel or splint coal. Very little fibrous coal and no apparent pyrites between the laminæ. Lumps slightly soiled with mud.

No. 1673— *Coal, from Little Clear Creek, &c., &c. Bed two feet thick, in the bed of the creek. Collected by A. R. Crandall.*"

Resembles the last. Some little ferruginous stain on exterior surfaces.

No. 1674—"*Coal, from Fork Ridge, on Stony Creek. A four-feet bed, above the cannel coal. Collected by A. R. Crandall.*"

A pitch-black, pure-looking coal. Has very little fibrous coal and no apparent pyrites.

No. 1675—"*Coal, from James Barnett's bank, six miles north of Cumberland Gap, on a branch of Clear Fork, which runs into Big Yellow Creek. Bed forty inches thick, with no shale parting. Average sample collected by Jno. H. Talbutt. (Three other beds in the same hill; one below, eighteen inches thick; two above—one eighteen inches, the other, on the top, about three to four feet thick.)*"

A pure, glossy, pitch-black coal. Has very little fibrous coal or pyrites.

No. 1676—"*Coal, from the same locality as the last. A sample from such as is sent to market.*" *Collected by John H. Talbutt.*"

Resembles the preceding.

COMPOSITION OF THESE BELL COUNTY COALS, AIR-DRIED.

	No. 1667.	No. 1668.	No. 1669.	No. 1670.	No. 1671.	No. 1672.	No. 1673.	No. 1674.	No. 1675.	No. 1676.
Specific gravity.	1.276	1.262	1.346	1.290	1.277	1.360	1.325	1.344	1.282	not est.
Hygroscopic moisture. . .	1.90	1.00	1.80	2.04	2.96	1.02	1.76	1.26	1.36	1.50
Volatile combus'ble matters	37.50	43.60	35.50	36.64	35.28	37.76	38.90	33.96	35.80	37.94
Coke	60.60	55.40	62.70	61.32	61.76	61.22	59.34	64.78	62.84	60.56
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters . . .	39.40	44.60	37.30	38.68	38.24	38.78	40.66	35.22	37.16	39.44
Carbon in the coke	57.90	47.80	52.20	58.02	59.40	48.22	52.54	55.42	59.54	58.40
Ash	2.70	7.60	10.50	3.30	2.36	13.00	6.80	9.36	3.30	2.16
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke. . .	*Lt. sp.	Dense sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.
Color of the ash	Light brown.	Buff-grey.	Very light grey.	Light lilac-grey.	Brownish-grey.	Lilac-grey.	Lilac-grey.	Light lilac-grey.	Buff-grey.	Brownish-buff.
Per centage of sulphur . .	1.519	0.590	0.956	0.736	0.420	1.670	2.027	2.672	0.975	1.038

*Lt. sp. — Light spongy.

These coals are all good, and some of them would rank amongst the very best, and might be made available in the smelting of iron ores without the preliminary process of coking, like the so-called "Block coal" of Indiana, which they resemble. The proportion of sulphur, it will be seen, is generally sufficiently low, but varies in the different samples from 0.42 per cent., in No. 1671, up to 2.672, in No. 1674. It must be remembered that these proportions given in the table represent the *total sulphur* of the coals, in whatever form it may exist in them, and that, in the practical use of the coal for smelting or manufacturing purposes, a considerable proportion of this total sulphur is removed in the preliminary heating in the upper part of the furnace, or in the coking of the coals, or is in such a state of combination in them as to be harmless.

As shown in volume I, new series, of these reports (lower page 287), some of this sulphur is in the free or uncombined condition, especially in the fibrous coal, or mineral charcoal, which is found between the laminæ. When in this state this injurious element is quite easily removable. Indeed, it is continually undergoing oxidation, when the coal is exposed to the air, even at the ordinary temperature, forming, with the atmospheric oxygen and moisture, sulphurous acid, which, being gaseous, is constantly escaping, causing the well-known sulphurous odor of the coal mine or coal heap, and enabling us to understand how it is that coals gradually become less sulphurous on exposure to the air. When the coals are heated the rate of the evaporation and oxidation of the sulphur is rapidly increased, so that at 300° F. or below it takes fire. Hence, none of the free sulphur of the coals used in the smelting of iron ever gets much below the top of the furnace, where it can do no harm, and all of it is burnt out even before the heat is sufficiently great to coke the coal. Possibly much of it escapes in the process of heating the coals to 212° F., with a view to ascertain the proportion of hygroscopic moisture, thus increasing the apparent quantity of that ingredient

—a supposition which will be made subject of further investigation.*

Some of the sulphur of coals exists in combination with iron, as sulphide or bi-sulphide. When it is in the form of bi-sulphide, one half of the sulphur of the compound is always burnt out in the process of coking, or in the upper part of the smelting furnace.

It will be seen, therefore, that while a portion of the sulphur of coals may, in the ordinary process of analysis, cause an error of excess in the estimation of the hygroscopic moisture, another portion increases the quantity of so-called volatile and combustible matters. Still another portion may, on incineration of the coke, be miscounted as fixed carbon.

That portion of the sulphur of coals which is not removed by the process of coking or preliminary heating is either in combination with iron, as iron proto-sulphide, which may injure the quality of the metal smelted with it, or it is most probably in combination with calcium, magnesium, or the alkaline metals, in which form it probably exerts little or no injurious action. Hence, as practical experience has measurably demonstrated, a coal may show a pretty large proportion of total sulphur in its chemical analysis, and yet answer for the smelting or working of iron when properly managed.

Even the iron proto-sulphide, which is the most injurious of all the forms of sulphur in coals or coke, may be easily removed, because it speedily oxidates into iron proto-sulphate when exposed to a moist atmosphere; and this salt, being quite soluble in water, is readily to be washed out.

It is interesting again to notice in this series of coals the pretty constant relation between the specific gravity and the ash per centage, as follows:

* As stated by Berzelius, all the sulphur may be burnt out of gunpowder at the heat of boiling water without exploding the powder. Examined in the dark, a faint flame appears above it, in this experiment.

Number.	Ash per centage.	Specific gravity.	Number.	Ash per centage.	Specific gravity.
1667	2.70	1.276	1668*	7.60	1.262
1671	2.36	1.277	1674	9.36	1.344
1675	3.30	1.282	1669	10.50	1.346
1670	3.30	1.290	1672	13.00	1.360
1673	6.80	1.325			

*A cannel coal.

Bell county, undoubtedly, is endowed with great wealth of coal of every good quality, as well as of iron ores, &c.; which only await development.

SOILS AND SUBSOILS OF BELL COUNTY.

No. 1677—"*Virgin Soil, John Turner's land, in the valley of Big Yellow Creek, three and a half miles west of Cumberland Gap. Bell county crawfish land; subject to overflow in high water. Timber: some trees five feet in diameter; burr-oak, beech, sweet gum, maples, poplar, sycamore, &c., &c. On the coal measures. Collected by John H. Talbutt.*"

Soil a light buff-grey color when dry; cloddy; clods mottled with light-ferruginous.

No. 1678—"*Old Field Soil, sixty years in cultivation, mostly in corn; John Turner's land. Same locality as virgin soil. Sample taken to the depth of thirteen inches. Field lies at the base of Fork Ridge of Canada Mountain, between Bennett's Fork and Stony Fork. An ancient mound exists on the same land, which is said to have had the remains of ancient earthworks on it. Many flint implements found on it. Collected by J. H. Talbutt.*" *Substratum of rounded sandstone boulders and pebbles; on coal measures.*

Soil of a light umber color.

No. 1679—"*Subsoil of the preceding, &c. Collected by J. H. Talbutt.*"

Subsoil of a light grey-buff color.

No. 1680—"*Virgin Soil to depth of three inches. Woods. B. F. Turner's land, three miles west of Cumberland Gap, on the foot-hills of Big Yellow Creek. Slope to the south. Timber: oak, beech, poplar, with underbrush. Coal measures. Collected by John H. Talbutt.*"

No. 1681—"*Subsoil to the preceding. Collected by J. H. Talbutt.*"

Subsoil of a buff color.

No. 1682—"*Soil from a field which has been cleared ten years. Has been six years in corn and four in pasture. Average yield thirty bushels of corn. Surface soil. The land slopes gently to the south. Woodland above it and to the north. Coal measures. Collected by John H. Talbutt.*"

Soil of a light buff-umber color.

No. 1683—"*Subsoil of the preceding. Collected by J. H. Talbutt.*"

Subsoil of a light buff-grey color.

No. 1684—"*Virgin Surface Soil, from the narrow plateau on the highest point of Brison Mountain, a fork of Mingo Ridge, near the line of Bell county. Eleven miles south-southeast of Cumberland Gap. Sample taken to the depth of nine inches. Underlying rock sandstone. Has on it a fair growth of chestnut, oak, sugar-tree, poplar, hickory, &c., &c. Collected by John H. Talbutt.*"

Soil of a dark grey-brown or umber color when dry; nearly black when wet.

No. 1685—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Subsoil of a lighter color and more sandy than the surface soil.

No. 1686—"*Vigin Soil, from the foot-hills of Mingo Mountain, Big Yellow Creek Valley. Land of William T. Moss. Slope to the north. Timber: black oak, dogwood, maple, chestnut, &c., &c. Sampled to the depth of ten inches by John H. Talbutt.*"

Soil of a dirty grey-buff color.

No. 1687—"*Soil from an old field fifty years in cultivation—thirty-five in corn without change, seven years thereafter in clover and grass, and then two years in corn; now in wheat. Average yield: of corn, forty bushels; of wheat, ten bushels. Timber was black walnut, burr-oak, poplar, gum, maple, sycamore, &c. Land of William T. Moss. In Big Creek Valley, near the head of Big Yellow Creek. Carboniferous formation. Top soil seventeen inches deep. Collected by John H. Talbutt.*"

Soil of a light, grey-umber color.

No. 1688—"*Subsoil to the preceding; taken eighteen inches below the surface. Collected by John H. Talbutt.*"

Subsoil lighter colored than the surface soil preceding.

No. 1689—"*Soil from an old field in cultivation seventy years. Farm of Henry Lane. Foot-hills of Mingo Mountains, Big Yellow Creek Valley, three and a half miles from Cumberland Gap. Cultivated for the last ten years in corn and wheat alternately; previous to which in corn for twenty-five years; now in wheat. Originally covered with a dense forest of black walnut, burr-oak, beech, poplar, sycamore, and gum. Yield of corn, thirty to forty-five bushels; of wheat, fifteen bushels. Value of the land, fifty dollars per acre. On the carboniferous formation. Sampled to the depth of fifteen inches, by John H. Talbutt.*"

Soil of a yellowish-grey, light umber color.

No. 1690—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Subsoil of a lighter and more yellowish color than the surface soil preceding.

No. 1691—"*Soil to the depth of nine inches from an old field now in corn, on John Colson's land, foot of Cumberland Range, near Cumberland Gap. Slope to the west. On coal measures. Collected by J. H. Talbutt.*"

Dried soil of a light, brownish-umber color. Contains many small fragments of decaying vegetable roots, &c., and some small rounded quartz pebbles, and fragments of ferruginous sandstone.

No. 1692—"*Subsoil of the preceding*," *&c., &c.*

Of an orange-grey-buff color. Much lighter colored and more cloddy and adhesive than the preceding, and containing fewer pebbles. The silicious residue of both of these, after digestion in acids, contained a considerable quantity of small rounded, clear quartz grains.

No. 1693—*Surface Soil to five inches in depth, from a field ten years in cultivation; now in corn, of which it yields about twenty bushels. J. C. Colson's land, one mile west of Cumberland Gap; foot-hills of Dark Ridge. Slope to the southeast. Carboniferous formation. Collected by John H. Talbutt.*"

Soil of a dirty buff-grey color. The coarse sieve removed from it some small fragments of ferruginous sandstone. The silicious residue all passed through fine bolting-cloth, except a very few small clear quartz grains.

No. 1694—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Resembles subsoil No. 1692, but is a little lighter colored and more cloddy. Contains no silicious sand.

No. 1695—"*Top Soil to depth of nine inches, from an old field fifty years in cultivation. For the last twenty-five years in corn, wheat, oats, and clover; two thirds of time in corn. Average yield of which, thirty bushels per acre. Does not produce good wheat or oats. J. C. Colson's land. North side of Big Yellow Creek Valley, near the foot-hills of Log Moun-*

tain, three miles northwest of Cumberland Gap. Carboniferous formation. Collected by John H. Talbutt."

Soil resembles No. 1693.

No. 1696—"*Subsoil of the preceding, taken one foot below the surface. By John H. Talbutt.*"

Subsoil of a reddish-brown, grey-buff color. Contains very few grains of fine quartz sand.

212

COMPOSITION OF THESE BELL COUNTY SOILS AND SUBSOILS, DRIED AT 212° F.

	No. 1677	No. 1678	No. 1679	No. 1680	No. 1681	No. 1682	No. 1683	No. 1684	No. 1685	No. 1686
Organic and volatile matters	4.700	5.575	2.600	5.725	2.750	5.050	1.800	11.565	5.750	4.050
Alumina, Iron peroxide, Manganese oxide	4.817	4.015	1.710	4.339	4.137	3.557	2.474	4.615	4.662	4.197
Lime carbonate	.190	.190	.115	.065	.065	.265	.115	.145	.145	.095
Magnesia	.338	.069	.045	.050	.042	.131	.060	.098	.079	.068
Phosphoric acid	.093	.220	.125	.096	.073	.093	.061	.125	.108	.093
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.164	.160	.056	.068	.106	.212	.086	.139	.131	.128
Soda	.115	.217	.006	.035	.032	. . . .	.014	.074	.039	not est.
Sand and insoluble silicates	89.390	88.875	93.940	89.390	92.090	90.215	95.115	84.040	88.540	90.440
Water, expelled at 380° F.	.600	.775	.900	.650	.850	.750	.750	.035	.900	.750
Loss	. . . .	. . . .	.503	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	.179
Total	100.407	100.096	100.000	100.418	100.145	100.273	100.475	100.836	100.354	100.000
Moisture, lost at 212° F.	1.825	2.550	1.350	1.800	0.875	1.875	0.850	3.700	2.275	1.475
Potash in the insoluble silicates	2.568	.735	.850	.568	.713	.347	.501	.583	.717	1.387
Soda in the insoluble silicates	.389	.018	.082	.119	.137	.167	.216	.090	.150	.213
Character of the soil	Virgin soil.	Old field	Subsoil.	Virgin soil.	Subsoil.	Old field	Subsoil.	Virgin soil.	Subsoil.	Virgin soil.

COMPOSITION OF THESE BELL COUNTY SOILS AND SUBSOILS, DRIED AT 212° F.—(Continued.)

	No. 1687	No. 1688	No. 1689	No. 1690	No. 1691	No. 1692	No. 1693	No. 1694	No. 1695	No. 1696
Organic and volatile matters	5.925	4.850	5.525	4.725	3.500	2.450	4.125	4.025	7.175	5.675
Alumina, Iron peroxide, Manganese oxide	8.846	8.120	7.339	7.013	2.913	2.815	5.990	6.997	9.626	12.816
Lime carbonate	.280	.095	.095	.095	.290	.275	.225	.225	.265	.115
Magnesia	.052	.088	.088	.088	.070	.044	.080	.081	.155	.322
Phosphoric acid	.124	.093	.061	.077	.093	.125	.125	.093	.189	.294
Sulphuric acid	not est.	not est.	not est.	not est.	.007	.003	.007	.007	.007	.013
Potash	.139	.191	.143	.243	.158	.203	.109	.368	.429	.443
Soda	.085	.117	.063	. . . .	.050	.013	.177	. . . .	.190	. . . .
Sand and insoluble silicates	83.140	86.040	85.140	87.125	92.090	92.040	87.590	86.815	80.040	78.240
Water, expelled at 380° F.	1.100	.750	1.200	1.000	1.100	1.050	1.450	1.250	2.075	2.025
Loss	.309	. . . .	.346	. . . .	. . . .	.982	.122	.139	. . . .	.057
Total	100.000	100.344	100.000	100.366	100.271	100.000	100.000	100.000	100.151	100.000
Moisture, lost at 212° F.	2.450	1.875	2.225	1.900	1.150	1.175	1.500	1.515	2.500	2.525
Potash in the insoluble silicates	2.509	2.275	2.362	2.351	.496	.674	1.831	1.964	2.519	2.640
Soda in the insoluble silicates	.344	.251	.273	. . . .	.169	.186	.561	.348	.303	.464
Character of the soil	Old field	Subsoil.	Old field	Subsoil.	Old field	Subsoil.	Field 10 years in cultiv'n.	Subsoil.	Old field	Subsoil.

As might have been expected, considerable local differences are exhibited by the chemical analyses of these mountain soils, caused, probably, in most cases, by the action of the drainage; as may be seen by comparing the relative proportions of the potash, phosphoric acid, the organic and volatile matters, lime, magnesia, and alumina, &c., &c., with the silex and insoluble silicates, as well as by the relative quantities of alkalies in the insoluble silicates.

Thus the soils of the valley, or those subject to overflow, as for example, Nos. 1687–'8–'9–'90, as well as 1693–'4–'5–'6, located in the valley, are richer than those on the mountain slopes. A remarkable difference in the proportions of phosphoric acid can be observed in soils Nos. 1677 and 1678, which may possibly have been caused by the residence on the latter of the prehistoric people who built and occupied the ancient earth-works located there.* The subsoil No. 1679, underlying the latter, is by no means as rich as the surface soil, based as it is on a substratum of rounded sandstone boulders and pebbles, and no doubt offering quite a free drainage to the waters from above, which tend to wash away the soluble ingredients.

The soil from the plateau, at the summit of Brison Mountain, No. 1684, is much richer than might have been expected. Its large proportions of organic and volatile matters, as well as of alkalies in the insoluble silicates, indicate the influence of the primeval forest growth, with which it is yet covered, in retaining the elements of fertility on the surface. The unusually large proportion of silicates, rich in alkalies, in the rock material from whence the soil was derived, may have been another cause.

BOONE COUNTY.

No. 1697—"CLAY, *from three miles west of Burlington. Sent by W. W. Walton.*"

Presents thin stratified layers of various tints of light-brownish-grey and light dove color. Burns hard, and of a

*A similar increase in the proportion of phosphates on and near the site of these prehistoric earth-works was observed in Fayette county, on the farm of the writer.

handsome light brick color. Melts at a high temperature; hence, is not a fire-clay.

COMPOSITION, DRIED AT 212° F.

Alumina, with iron and manganese oxides and phosphoric acid	33.060
Silica	48.360
Lime	3.057
Magnesia	.367
Potash	4.664
Soda	1.706
Combined water and loss	8.786
Total	100.000

While its large proportions of alkalies and of lime, as well as of iron oxide, prevent it from withstanding the melting influence of a high heat, it may yet be quite available for so-called *terra cotta* articles. It is probable, also, that, if found in sufficient quantity, it may be quite useful in the improvement of worn-out sandy soils in its vicinity.

BOYD COUNTY.

No. 1698—"GREY LIMESTONE ORE, *from J. P. Jones' drift, near Ashland. Collected by P. N. Moore.*"

Interior portion—Grey clay iron-stone, made up of fine light-brownish granules, embedded in a whitish material. *Exterior portion*—Generally dark reddish-brown, with some little lighter ferruginous and ochreous, the whole exhibiting a fine granular or oölitic structure, and showing the same whitish material observed in the grey interior portion.

The analyses of the interior and exterior portions were made separately, with a view to the study of the changes which occur when clay iron-stone is changed into limonite.

Similar comparative analyses are recorded under Carter county.

No. 1699—"YELLOW KIDNEY ORE. *Point of hill. Catlettsburg, Boyd county. Collected by A. R. Crandall. A cabinet specimen.*"

A kidney of fine-grained iron carbonate, invested with thin layers of reddish and yellowish-brown and brownish-yellow limonite.

Interior and exterior portions separately analyzed.

COMPOSITION OF THESE ORES, DRIED AT 212° F.

	No. 1698.		No. 1699.	
	Interior.	Exterior.	Interior.	Exterior.
Iron carbonate	62.002	none.	69.912	none.
Iron peroxide	none.	65.395	none.	61.142
Alumina	2.900	3.484	6.128	7.964
Manganese carbonate	.553	. . . .		. . .
Manganese oxide	. .	not est.	not est.	not est.
Lime carbonate	6.880	8.580	8.280	3.530
Magnesia	*2.243	1.938	*3.314	.424
Phosphoric acid	.149	.441	.686	.414
Sulphuric acid	.302	.336	.147	.199
Combined water	. . . . .	9.316	. . . . .	12.600
Silicious residue	22.660	10.480	8.930	14.180
Total	97.689	100.000	97.397	100.453
Per centage of iron	29.932	45.776	33.751	42.799
Per centage of phosphorus	.065	.192	.299	.181
Per centage of sulphur	.121	.134	.059	.080
Per centage of silica	16.360	9.360	7.460	11.860

*Carbonate.

Taking for a basis of comparison the relative quantities of *iron* in the two portions, which are nearly in the proportions of one in the interior part to one and a half in the exterior in No. 1698, and somewhat less in No. 1699 (or as 1 : 1.27), we find that in the former there has been a notable increase of phosphorus, a slight increase of lime, a great diminution in the proportion of silica, and slight diminutions in the proportions of sulphur, magnesia, and alumina; in specimen 1699, a decrease in the phosphorus, and an increase in the sulphur, silica, and alumina. The lime and magnesia are also greatly diminished. So that there seems to be no regular law in relation to the changes which occur; which may be effected by very varying conditions of chemical action and infiltration.

PIG IRONS FROM BOYD COUNTY.

No. 1700—"*Pig Iron. Hot-blast. Mill iron, from Bellfonte Furnace. Collected by P. N. Moore.*"

A fine-grained, dark-grey iron. Yields readily to the file. Extends quite considerably under the hammer.

No. 1701—"*Hot-blast, Silver-grey Iron, Bellfonte Furnace. Collected by P. N. Moore.*"

Coarser grained than the preceding; somewhat harder and more brittle. Of a light silver-grey color.

COMPOSITION OF THESE PIG IRONS.

	No. 1700.	No. 1701.
Specific gravity	6.921	6.163
Iron	92.962	89.902
Graphite	2.100	2.900
Combined carbon	1.310	.070
Silicon	2.525	5.082
Slag	.220	.280
Phosphorus	.568	.417
Sulphur	.114	.114
Other ingredients	not est.	not est.
Total	99.799	98.765
Total carbon	3.410	2.970

The principal difference in the composition of these two samples is in the much larger proportion of silicon and somewhat smaller amount of iron in No. 1701.

BREATHITT COUNTY.

COALS FROM BREATHITT COUNTY.

No. 1702—"*Coal, from Roberts' bank, on Troublesome Creek. Upper seam. The so-called bituminous coal. Collected by P. N. Moore.*"

A splint coal, splitting into very thin laminæ, with fibrous coal between, but with no appearance of pyrites. The sample has a weathered and tarnished appearance, showing ferruginous and earthy stains. Hence, the ash per centage found is greater than that of the clean coal of the interior of the bed.

No. 1703—"*Coal, from Roberts' bank, Troublesome Creek. Sample from the lower part of the bed, called cannel coal. Averaged by P. N. Moore.*"

A pure-looking coal, with but little fibrous coal and no apparent pyrites. Sample somewhat mixed in character. Some pieces of cannel coal; others splint coal; others apparently shaly.

No. 1704—"*Coal, from the same bank. Sample from the middle part of the seam. Called bituminous. Collected by P. N. Moore.*"

Rather a dull-looking coal. Apparently pretty pure, having but little apparent fibrous coal or pyrites between its laminæ. Exterior of some of the lumps covered with ferruginous incrustation.

No. 1705—"*Cannel Coal. Haddock's bed. North Fork of Kentucky river, above the mouth of Troublesome Creek. Collected by P. N. Moore.*"

A very tough coal. Sample somewhat tarnished by weathering, &c., showing ferruginous and clayey incrustation on parts of the surfaces, which may probably make the ash per centage found greater than that of the bed. It has but little fibrous coal, but some evident pyrites.

See volume I, page 354, old series, &c., for other analyses of this coal.

No. 1706—"*Cannel Coal. G. W. Johnson's. Nichol's Fork of Frozen Creek. Sample from near the outcrop. Collected by P. N. Moore.*"

A dull-black coal, very difficult of fracture. Has some little appearance of bright pyrites, and some ferruginous incrustation. No fibrous coal. Some of the seams beautifully polished.

No. 1707—"*Cannel Coal. G. W. Johnson's. Same locality as the preceding. From another outcrop. Sample from hand specimen only.*"

Similar in appearance to the preceding.

No. 1708—*Coal, from Frozen Creek, a quarter of a mile above Wm. Day's. Collected by P. N. Moore.*"

A pure-looking splint coal. Has very little fibrous coal and some little fine granular pyrites between the laminæ; is easily fractured.

No. 1709—"*Cannel Coal. Quicksand Creek. Alfred Little's drift. Collected by John R. Procter.*"

Contains some small bright scales of pyrites. Some portions give an imperfect bird-eye fracture; others show an imperfect fibrous structure, somewhat like that of lignite. Coal generally tough.

No. 1710—"*Coal, from Jackson Wells' bank. Near the mouth of Troublesome Creek. Sample from the outcrop, where the coal is dirty, and hence will give somewhat more than the average ash per centage. Collected by P. N. Moore.*"

A splint coal, with thin partings of fibrous coal containing fine granular pyrites.

No. 1711—"*Cannel Coal, from George's Creek. Collected by P. N. Moore.*"

A pure-looking coal. Has some ferruginous stain on the exterior surfaces, but no apparent pyrites.

No. 1712—"*Coal, from Simon Holland's bank. Collected by P. N. Moore.*"

A pure-looking, splint coal, with not much fibrous coal between the laminæ, and no apparent pyrites. Easily fractured.

No. 1713—"*Coal, from Wolf Creek bank. Collected by J. R. Procter and P. N. Moore. Sample from coal long weathered.*"

A pure-looking, soft splint coal, in thin laminæ, which have quite a glossy cross fracture. Very little fibrous coal or fine granular pyrites between the laminæ.

No. 1714—"*Coal, from William Spencer's mine. North Fork of Kentucky river. Collected by P. N. Moore.*"

A bright, pure-looking coal, showing very little fibrous coal or granular pyrites.

COMPOSITION OF THESE BREATHITT COUNTY COALS, AIR-DRIED.

	No. 1702.	No 1703.	No. 1704.	No. 1705.	No. 1706.	No. 1707.	No. 1708.	No. 1709.	No. 1710.	No. 1711.	No. 1712.	No. 1713.	No. 1714.
Specific gravity	1.405	1.280	1.290	1.265	1.360	1.180	1.300	1.328	1.398	1.280	1.290	1.290	1.297
Hygroscopic moisture	3.30	3 40	2.20	1.30	1.60	1.20	2.50	2.10	2.78	0.94	4.90	2.76	3.56
Volatile combustible matters	31 44	43 40	39.20	47.00	43.20	58 80	41.10	43.10	35.52	52.38	35.30	36.68	33.56
Coke	65.26	53.20	58.60	51.70	55 20	40.00	56.40	54.80	61.70	46.68	59.80	60.56	62.88
Total	100 00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	34.74	46.80	41.40	48.30	44.80	60.00	43.60	45.20	38.30	53.32	40 20	39.44	37.12
Fixed carbon in the coke	49.76	46.96	51.14	44.40	33.80	35.30	49.22	43.36	44.94	35.54	55.50	56.50	58.38
Ash	15.50	6.24	7.46	7.30	21.40	4.70	7.18	11.44	16.76	11.14	4.30	4.06	4.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense friable.	Friable.	Spongy.	Dense.	Pulverulent.	Dense.	Light spongy.	Spongy.	Dense spongy.	Dense.	Spongy.	Light spongy.	Light spongy.
Color of the ash	Pinkish-grey.	Light buff-grey.	Lilac-grey	Brownish-grey.	Light buff.	Light grey-buff.	Dark lilac.	Light grey	Light lilac-grey.	Light lilac-grey.	Light grey	Light yellowish-grey.	Light lilac-grey.
Per centage of sulphur	0.991	0.630	2.525	1.574	2.549	not est.	0.818	4.609	1.423	1.423	3.153	0.865	1.381

These coals are, generally, superior in quality to the average. Some few of them contain an inordinate proportion of ash; but this will not prevent them from being quite valuable as fuel. The per centage of sulphur in them is generally low. Some, however, exceed somewhat in this respect, especially No. 1712, which contains much more than is indicated by its external appearance, amounting to about three fourths of the weight of the ash—a fact which shows that much of it is in a free state, or in organic combination in the coal.

The usual relationship of specific gravity to ash per centage is shown in these coals, as follows:

Number.	Ash per centage.	Specific gravity.	Number.	Ash per centage.	Specific gravity.
1713	4.00	1.290	1704†	7.46	1.290
1712	4.30	1.290	1711*	11.14	1.280
1714	4.50	1.297	1709*	11.44	1.398
1707*	4.70	1.180	1702	15.50	1.405
1703	6.24	1.280	1710	16.76	1.398
1708	7.18	1.300	1706*	21.40	1.360
1705*	7.30	1.265			

* A cannel coal. † Partly cannel.

The cannel coals are well known to be less dense than the splint and bituminous, and hence show a discrepancy in the comparison instituted. They contain a much larger quantity of hydrogen also, as exhibited in their large proportion of volatile combustible matters, as shown in the above table.

CARTER COUNTY.

No. 1715—"BLOCK ORE. *Joe Harris'. Jordan Branch of Tygert's Creek. Collected by A. R. Crandall.*" *A cabinet specimen.*

A kidney of dark-grey, fine granular iron carbonate, invested with concentric layers of limonite ore (hydrated peroxide) of various tints, from dark-brown to brownish yellow.

The interior and exterior parts were submitted to analysis separately, as were Nos. 1698 and 1699 (which see), for the purpose of studying the causes of the change from carbonate to limonite.

COMPOSITION, DRIED AT 212° F.

	Interior.	Exterior.
Iron carbonate	33.189	. . . .
Iron peroxide	5.616	42.548
Alumina and manganese oxide	27.105	22.984
Lime carbonate	12.180	5.180
Magnesia carbonate	1.095	. . . .
Magnesia	. . . .	.119
Phosphoric acid	2.060	2.218
Sulphuric acid	a trace.	a trace.
Water and loss	4.375	7.671
Silicious residue	14.380	19.280
Total	100.000	100.000
Per centage of iron	19.953	29.953
Per centage of phosphorus	.899	.968
Per centage of sulphur	a trace.	a trace.
Per centage of silica	14.300	19.280

The relative proportion of iron is notably increased in the limonite; the water, phosphoric acid, and silica are also increased; while the lime, magnesia, and alumina are diminished: indicating, like the previous analyses above referred to, no regular order of change.

PIG IRON OF CARTER COUNTY.

No. 1716—"*Hot-blast Mill Iron, from Mount Savage Furnace. Collected by P. N. Moore.*"

A dark-grey, fine-grained iron. Yields to the file; extends considerably under the hammer.

No. 1717—"*Hot-blast No. 2 Foundry Iron. Mount Savage Furnace. Collected by P. N. Moore.*"

A moderately fine-grained iron. Yields to the file; extends somewhat under the hammer.

No. 1718—"*Hot-blast, Silver-grey Iron, from Mount Savage Furnace. Collected by P. N. Moore.*"

Whiter, coarser grained, and more brittle than the preceding.

COMPOSITION OF THESE MOUNT SAVAGE PIG IRONS.

	No. 1716.	No. 1717.	No. 1718.
Specific gravity	6.930	7.042	7.435
Iron	93.268	91.584	89.687
Graphite	3.950	2.600	2.300
Combined carbon	.770	1.070	.500
Silicon	1.799	3.058	5.575
Slag	.160	.620	.660
Phosphorus	.680	.609	.609
Sulphur	.081	.152	.136
Total	100.708	99.693	99.467
Total carbon	4.720	3.670	2.800

A regular diminution in the proportions of iron and carbon from No. 1716 to 1718, together with a similar increase in the proportions of silicon, slag, and sulphur, as well as of the specific gravity, may be noticed in these samples, corresponding with the quality of the iron. The phosphorus, which is in full average quantity, seems more constant.

CHRISTIAN COUNTY.

COALS.

No. 1719—"*Coal I, from Coalton banks. Sample from the stock pile. Collected by C. J. Norwood.*"

A glossy, black splint coal, breaking into thin laminæ, with very little fibrous coal and some little granular pyrites between them.

No. 1720—"*Coal L, from two miles south of Petersburg. Sampled for analysis by C. J. Norwood.*"

A splint coal, showing fibrous coal and some pyrites. Sample appears to have been weathered.

No. 1721—"*Coal J. At Petersburg Station. St. Louis and Southeastern Railroad. Miners' Coöperation Mine. Average sample by C. J. Norwood.*"

A dull-looking splint coal, but glossy on the cross-fracture of the thin laminæ, between which there is some fibrous coal and granular pyrites.

COMPOSITION OF THESE CHRISTIAN COUNTY COALS, AIR-DRIED.

	No. 1719.	No. 1720.	No. 1721.
Specific gravity	1.307	1.332	1.398
Hygroscopic moisture	4.60	5.10	3.70
Volatile combustible matters	31.94	32.50	32.56
Coke	63.46	62.40	63.74
Total	100.00	100.00	100.00
Total volatile matters	36.54	37.60	36.26
Fixed carbon in the coke	54.36	55.70	50.04
Ash	9.10	6.70	13.70
Total	100.00	100.00	100.00
Character of the coke	Dense.	Very dense	Light spongy.
Color of the ash	Light lilac-grey.	Light lilac-grey.	Greyish-brown.
Per centage of sulphur	1.469	1.277	3.716

MINERAL WATER OF CHRISTIAN COUNTY.

No. 1722—"*Salt Sulphur Water, from a bored well five inches in diameter; bored one hundred and thirty-four feet deep; on the premises of Mr. John B. Trice, Hopkinsville.*" *Bored through solid rock, except through the first sixteen feet.*

The water stands at about one hundred feet higher in the well than the level of the lowest part of the town.

The sample of the water, although brought to the laboratory in a well-corked stone jug, had lost its free hydrosulphuric acid. It smelt slightly sulphurous, and tasted pleasantly saline. It had a light greenish-yellow tint, indicative, probably, of the presence of a little sulphuretted sulphide. It exhibited a slightly alkaline reaction with reddened litmus.

SPECIFIC GRAVITY = 1.005 TO 1.006.

COMPOSITION IN 1000. PARTS.

Lime carbonate	0.1223	Held in solution in the water by carbonic acid.
Magnesia carbonate	.0253	
Iron and manganese carbonates, with a trace of alumina	.0013	
Silica	.0112	
	0.1601	In the sediment formed on boiling.
Sodium chloride	3.3647	
Sodium sulphide	not estimated.	
Soda carbonate	.2366	
Soda sulphate	.5347	
Potassium chloride	a trace.	
Lime sulphate	.1156	
Magnesia sulphate	.4329	
Magnesium iodide	.0018	
Lithia and bromine	marked traces.	
	4.6863	In the boiled water.
Total saline contents	4.8464	In 1000. parts of the water.

The water at the well contains free hydrosulphuric and carbonic acids, the proportions of which can only be found by operation on the freshly drawn water.

The analysis of this water shows it to be quite a good *salt sulphur water*, which may be made available in the treatment of many diseases under proper medical advice.

SOILS OF CHRISTIAN COUNTY.

No. 1723—"*Virgin Soil, from woods adjoining the cultivated field from which the next described soil was taken. Farm of H. C. McCord. Crofton Station. On the flats. Underlying rock sandstone. Collected by C. W. Beckham.*"

Dried soil of an ashy-grey color. It contains a small quantity of shot iron gravel. The silicious residue, after digestion in acids, all passed through bolting-cloth, except a few small angular grains of white and red quartz.

No. 1724—"*Surface Soil, from a field fifteen years in cultivation, adjoining the woodland from which the preceding sample was taken. (Principal crops cultivated, corn and tobacco.) Collected by C. W. Beckham.*"

Dried soil of a brownish-grey color; much darker colored than the preceding. Contains a little iron gravel. Silicious residue contained fewer quartz grains.

No. 1725—"*Subsoil of the next preceding. Collected by C. W. Beckham.*"

Dried soil of a grey-buff color; contains a little iron gravel. Silicious residue like next preceding.

No. 1726—"*Virgin Soil; farm of S. W. Williams. St. Louis and Southeastern Railroad. Petersburg. Forest growth principally oaks. Collected by C. W. Beckham.*"

Dried soil of a light brownish-grey color; contains very little iron gravel. Silicious residue passed through bolting-cloth, except a few fine round grains of clear quartz.

No. 1727—"*Surface Soil, from an old field forty-five years in cultivation in corn and tobacco; on same farm, and about a quarter of a mile distant. Field about thirty feet above the flats. Collected by C. W. Beckham.*"

Dried soil of a grey-buff color; contains no gravel. No quartz grains in the silicious residue.

No. 1728—"*Subsoil of the next preceding,*" *&c.*

Dried soil of a light yellowish-brown color; contains no gravel or quartz grains.

No. 1729—"*Virgin Soil, from the farm of Mr. Durty, near Hopkinsville. Forest growth: cedar, white and red oak, black jack, white walnut, &c. Underlying rock very compact limestone. Collected by C. W. Beckham.*"

Dried soil of a light-greyish color; contains no gravel. The silicious residue passed through bolting-cloth, with the exception of a few small angular quartz grains.

No. 1730—"*Surface Soil, from an old field about fifty years in cultivation in corn, tobacco, and wheat. From the same farm as the next preceding. Collected by C. W. Beckham.*"

Dried soil of a light yellowish-grey-brown color. The bolting-cloth separated but few small angular quartz grains from the silicious residue.

No. 1731—*Subsoil of the next preceding, &c., &c.*

Dried soil of a light brick color. Silicious residue contains a few small angular quartz grains.

No. 1732—"*Virgin Soil; farm of E. F. Kelly. Kelly's Station, on the L. & E. E. Railroad, eight miles north of Hopkinsville. Underlying rock, sandstone. Principal forest growth: white, black, and post oaks and hickory. Collected by C. W. Beckham.*"

Soil of a dirty-buff color. All passed through the coarse sieve, except two small ferruginous concretions. The silicious residue all passed through bolting-cloth, except a few small grains of clear quartz and of reddish silicate.

No. 1733—"*Surface Soil, from a field fifty years in cultivation; principal crops tobacco and corn. From the same farm as the next preceding. Collected by C. W. Beckham.*"

Dried soil of a light grey-brown color; contains no gravel. Silicious residue contains a few more small quartzose grains than preceding.

No. 1734—"*Subsoil of the next preceding. Collected by C. W. Beckham.*"

Dried soil of a dark grey-buff color; contains no gravel and very few fine quartzose grains.

No. 1735—"*Virgin Soil, from woods. Farm of Mr. Campbell, near Hopkinsville. Underlying rock, limestone. Collected by C. W. Beckham.*"

Dried soil of a dirty, dark-grey color; contains no gravel. The silicious residue all passed through the bolting-cloth, except a few quartzose grains, clear and reddish and blackish, and a small silicified entrochite.

No. 1736—"*Surface Soil, from an adjoining field, about forty years in cultivation, in corn and tobacco and meadow. Collected by C. W. Beckham.*"

Dried soil of a light-grey-brown color; contains no gravel. The bolting-cloth separated more fine quartzose and entrochi from the silicious residue than from that of the preceding.

No. 1737—"*Subsoil of the next preceding*," *&c., &c.*

Dried soil of a light brick color; contains no gravel. Silicious residue contains about the same proportion of quartzose grains, &c., as that of the preceding.

229

COMPOSITION OF THESE CHRISTIAN COUNTY SOILS, DRIED AT 212° F.

	No. 1723	No. 1724	No. 1725	No. 1726	No. 1727	No. 1728	No. 1729	No. 1730	No. 1731	No. 1732	No. 1733	No. 1734	No. 1735	No. 1736	No. 1737
Organic and volatile matters	4.200	4.360	3.135	3.300	4.330	4.065	5.165	4.065	3.600	2.625	2.925	2.775	4.675	3.115	3,500
Alumina and iron and manganese oxides	4.810	6.467	9.310	3.922	6.402	12.155	5.540	4.618	11.193	4.036	5.992	9.052	4.127	5.884	12.727
Lime carbonate	.065	.125	.120	.095	.220	.160	.270	.270	.295	.130	.170	.070	.190	.270	.295
Magnesia	.155	.151	.139	.115	.106	.164	.178	.124	.142	.097	.153	.156	.167	.151	.232
Phosphoric acid	.125	.068	.150	.038	.108	.080	.070	.042	.093	.124	.093	.108	.108	.086	.108
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.135	.176	.083	.121	.247	.637	.385	.256	.457	.121	.125	.174	.260	.210	.707
Soda	. . . .	.261	.116	.172	.153	.084	. . . .	. . . .	. . . .	.125	. . . .	. . . .	. . . .	. . . .	.289
Water expelled at 380° F.	.475	.500	.375	.250	.325	.450	.595	.445	.400	.450	.550	.600	.725	.550	.750
Sand and insoluble silicates	89.940	88.710	86.290	91.850	87.925	81.890	88.615	88.915	83.645	92.625	89.755	86.575	89.765	89.815	31.890
Loss	.095	. . . .	.282	.137	.184	.315	. . . .	1.265	.175	. . . .	.237	.490	. . . .	. . . .	. . . .
Total	100.000	100.818	100.000	100.000	100.000	100.000	100.818	100.000	100.000	100.333	100.000	100.000	100.017	100.081	100.498
Hygroscopic moisture	1.725	1.740	1.900	0.925	1.500	2.800	1.710	1.590	3.000	1.050	1.365	2.165	1.600	1.400	3.135
Potash in the insoluble silicates	0.925	.980	1.131	1.462	1.457	1.367	1.669	1.642	1.516	1.421	1.166	1.368	1.304	1.263	.707
Soda in the insoluble silicates	.434	479	.561	.569	.875	1.044	.478	.605	.662	575	.420	.461	.545	.325	.289
Character of the soil	Virgin soil.	Cultivated field.	Subsoil.	Virgin soil.	Old field soil.	Subsoil	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

Several facts may be noticed, in a comparative view of these soils; especially that the soils based on limestone are richer in essential mineral ingredients than those on the sandstone; that the soil on the very compact limestone is not so rich as that on the more friable rock; and that the subsoil, as a general rule, containing more alumina and iron oxide, &c., in proportion to the insoluble silicates, is generally richer in potash, phosphoric acid, and other essential ingredients, than the surface soil. Another fact, very generally to be noticed in the comparative analyses of soils is, that, except in certain anomalous cases, and where a richer subsoil has been mixed with the surface soil by the processes of culture, the old field soil generally exhibits, in its analysis, a diminution of the proportions of the essential mineral ingredients, as well as of organic and volatile matters, and an increase of the proportion of sand and insoluble silicates.

CLAY COUNTY.

SALT WATER.

No. 1738—"*Salt water, from Goose Creek Salt-works, as it is pumped from the well. Sent by General T. T. Garrard, of Manchester.*"

The water came in a stone-ware jug, which was stopped with a corn-cob. It was slightly turbid or opalescent, probably because of the escape of some of its carbonic acid, and the consequent precipitation of part of its earthy carbonates, &c.

COMPOSITION IN 1000. PARTS.

SPECIFIC GRAVITY = 1.065.

Lime carbonate	0.0048	Held in solution by carbonic acid, and precipitated on boiling the water.
Magnesia carbonate	a trace.	
Iron and manganese carbonates	.0038	
Alumina, phosphoric acid, and silica	.0140	
Sodium chloride (common salt)	65.0000	
Calcium chloride	18.8960	
Magnesium chloride	5.0080	
Barium chloride	.3930	
Strontium chloride	.0843	
Lithium chloride	a trace.	
Potassium chloride	a trace.	
Iodine and bromine	a trace.	
Total saline matters (dried at 212°)	89.4039	In 1000. parts of the water.

231

A remarkable circumstance is the existence, in this Goose creek brine, of notable quantities of barium and strontium chlorides. The former salt is present in quantity equal to nearly twenty-three grains to the wine gallon of the water, and the latter in the proportion of nearly five grains. As it is well known that the soluble salts of barium exert an injurious influence on the animal economy, it is important that this should be removed in the manufacture of the salt. It is fortunate that this may be very easily and economically done by the addition of sulphate of soda, Glauber's salt, which, added in the quantity of about forty-five to fifty grains of this crystalline salt to the gallon of the fresh brine, will completely precipitate all the barium and strontium in the form of insoluble sulphates, and doubtless also aid in the clarification of the brine.

The cheap salt, sulphate of alumina, in equivalent quantity, would produce the same effect, and perhaps aid more completely in the clarification. Soda ash, carbonate of soda, would be equally effectual.

Barium and strontium salts are also present in the brine of the Glenfont Salt-works of Meade county, but in somewhat smaller proportions. Of course, where these salts are present we find no sulphates in the water.

No. 1739—"*The Bittern Water, left after graining the salt.*" *Goose Creek Salt-works.*

COMPOSITION IN 1000. PARTS.

SPECIFIC GRAVITY = 1.309.

Calcium chloride	350.49
Magnesium chloride	92.38
Sodium, potassium, and lithium chlorides	24.53
Barium and strontium chlorides	not est.
Sodium bromide	5.27
Sodium iodide	not est.

Various useful applications have been made of the bittern water of Salt-works; as in the preparation of bromine and the manufacture of artificial stone. Doubtless it might also be

used (if, like this, it contains much calcium chloride) in setting free the alkalies, contained in the form of insoluble silicates, in some of our marls and clays of the character of the Leitchfield marls. This may probably be done by mixing the marl with a considerable quantity of lime or powdered limestone, making the mixture up into a plastic mass, with the bittern water sufficiently concentrated by evaporation, and then calcining, at a low red heat, the properly prepared lumps or bricks of the mixed materials. These lumps or bricks, if properly calcined, will slack into a crumbling mass when exposed to moisture, in which the alkaline ingredients will be in a soluble condition, available for plant nourishment.

No. 1740—"*The deep-brownish or Spanish-brown colored deposit adhering to the interior of the wooden tube (or "gum") which conducts the brine from the well to the pans. Goose Creek Salt-works.*"

COMPOSITION, DRIED AT 212° F.

Iron peroxide	74.304
Alumina, phosphoric acid, &c.	7.016
Lime carbonate	.280
Magnesia carbonate	.680
Silicious residue	6.890
Saline matters and loss	10.830
Total	100.000

CLINTON COUNTY.

No. 1741—"MARLY CLAY. *Cumberland City mines. Chester Group. (Leitchfield marls.) Collected by N. S. Shaler.*"

A dull olive-grey, indurated marly clay.

COMPOSITION, DRIED AT 212° F.

Silica	70.800
Alumina, with a little iron and manganese oxides and phosphoric acid	18.840
Lime	*.594
Magnesia	4.358
Phosphoric acid	not est.
Sulphuric acid	not est.
Potash	4.240
Soda	.794
Total	99.626

* Equal to 1.060 per cent. of lime carbonate.

(See Grayson county in this and the preceding Chemical Report for similar marls.)

No. 1742—"COAL, *from the Cumberland mines. Conglomerate main coal. Collected by N. S. Shaler.*"

A pure-looking, pitch-black coal, with very little fibrous coal or pyrites.

SPECIFIC GRAVITY = 1.329.

COMPOSITION, AIR-DRIED.

Hygroscopic moisture	1.56
Volatile combustible matters	37.74
Coke	60.70
Total	100.00
Total volatile matters	39.30
Carbon in the coke	50.20
Ash	10.50
Total	100.00
Character of the coke	Light spongy.
Color of the ash	Light lilac-grey.
Per centage of sulphur	2.911

DAVIESS COUNTY.

MINERAL WATERS OF DAVIESS COUNTY.

No. 1743—"*Chalybeate Water, from Murray's Spring, near Lewis. (E., O. & N. R. R.) Collected by Capt. R. S. Triplett.*"

It came to hand in a stone-ware jug, stopped with a corn-cob, which may have somewhat altered the character of the water. The reaction of the water is neutral. No effort was made to estimate its gases.

COMPOSITION IN 1000. PARTS OF THE WATER.

Lime carbonate	0.1155	Held in solution in the water by carbonic acid, and precipitated on boiling.
Magnesia carbonate	.0046	
Iron carbonate	.0229	
Alumina	.0027	
Phosphoric acid	.0004	
Silica	.0107	
Lime sulphate	.0204	
Magnesia sulphate	.0768	
Potash sulphate	.0403	
Soda sulphate	.0476	
Sodium chloride	.0146	
Lithium chloride	.0013	
Silica, &c.	.0142	
Total saline matters	0.3720	Dried at 212° F.

It is doubtless a valuable saline chalybeate water.

MINERAL WATERS *from Dr. Hickman's Springs. Crow's Station (E., O. & N. R. R.). Coal measures. Daviess county. Collected by C. J. Norwood, as follows:*

No. 1744—"*Alum Spring*" (*labeled No.* 1).

This water has a brownish color and a strong acid reaction. The cork of the jug was blackened by the presence of iron salt.

No. 1745—"*Alum Spring*" (*labeled No.* 2).

This water resembles the preceding, but is of a lighter color.

No. 1746—"*Alum Spring*" (*labeled No.* 6). "*Sweet Spring.*"

Resembles No. 2 in the appearance of the water.

No. 1747—"*Sulphur Spring*" (*labeled No.* 3).

Reaction neutral. Has no peculiar taste or smell, having lost all its sulphuretted hydrogen gas.

No. 1748—"*Brick Spring*" (*labeled No.* 4).

Resembles the next preceding.

No. 1749—"*Yellow Spring*" (*labeled No.* 5).

The water has a slightly astringent taste; no color. In reaction is neutral.

All the alum waters deposited a brownish ochreous sediment on standing, which is mainly basic persulphate of iron, as shown by the following analysis (made by my son, Alfred Meredith Peter, who also made the analyses of the several waters, under my general supervision), as follows:

One thousand parts of the water. No. 1 (*i. e.*, No. 1744) gave on boiling 0.1938 part of brownish precipitate, dried at 212°, which became bright red on ignition, and had the following described

COMPOSITION, DRIED AT 212° F.

Iron peroxide	78.64
Combined water	14.74
Sulphuric acid (anhydride)	5.24
Silica	.64
Loss	.74
Total	100.00

COMPOSITION OF THE ALUM WATERS IN 1000. PARTS.

	No. 1744[1]	No. 1745[2]	No. 1746[6]
Basic iron persulphate (Fe_2O_3, $2SO_3$)	0.8756	0.0484	0.1460
Alumina sulphate	1.2468	.3303	.3500
Manganese sulphate	.0032	.0102	.0721
Lime sulphate	.5996	.3947	.3271
Magnesia sulphate	.3330	.3315	.2513
Potash sulphate	.0005	.0068	.0074
Soda sulphate	.0724	.2959	. . . . .
Copper sulphate	.0009	. . . . .	. . . . .
Sodium chloride	.0031	.0127	.0651
Lithia	a trace.	a trace.	a trace.
Silica	.0013	.0014	.0022
Organic matters and loss	. . . . .	.0279	.1878
Total saline matters, dried at 212° F.	3.1364	1.4598	1.4090
Specific gravity of the water	1.00304	1.00164	1.00162

COMPOSITION OF THE "SULPHUR," "BRICK," AND "YELLOW" SPRING WATERS IN 1000. PARTS.

	No. 1747(3)	No. 1748(4)	No. 1749(5)
Iron and manganese oxides	traces.	0.0004	0.0018
Lime carbonate	0.1106	.1196	.0256
Magnesia carbonate	.0196	.0331	.0211
Lime sulphate	.1306	.0838	.1379
Magnesia sulphate	.1594	.1057	.0651
Potash sulphate	.0035	.0129	.0103
Soda sulphate	.4567	.5019	.2082
Sodium chloride	.0809	.0213	.0127
Lithia	traces.	traces.	traces.
Copper	.....	.....	a trace.
Silica	.0174	.0254	.0298
Organic matters and loss	.0373	.....	.0357
Total saline matters, dried at 212° F.	1.0160	0.9041	0.5482
Specific gravity of the water	1.00115	1.00120	1.00086

These alum waters, doubtless of analogous composition with others of the name in Virginia and elsewhere, are highly astringent, and are doubtless too strong for internal use without dilution, in most cases. They will find their remedial applications, however, under the advice of the educated physician. The saline and sulphur waters would prove alterative, slightly aperient, diuretic, or sudorific and hence depurative, according to the manner of their administration, under medical advice. The small amount of copper in the alum waters will not materially affect their influence.

SOILS OF DAVIESS COUNTY.

No. 1750—"*Virgin Soil, from the farm of H. Riley, on the E., O. & N. R. R., fifteen miles from Owensboro. On a hill-top. Collected by C. W. Beckham.*"

Soil of a light grey-brown color; contains no gravel. The bolting-cloth sieve separated from its silicious residue a considerable quantity of fine, rounded quartz grains, both hyaline and opaque.

No. 1751—"*Surface soil, from an old field sixty-five years in cultivation, in corn and tobacco principally; now overgrown with sassafras. Same locality as the preceding. Collected by C. W. Beckham.*"

Soil of a lighter and more yellowish light-grey-brown color; has no gravel. Silicious residue contained very few small quartz grains.

No. 1752—"*Subsoil to the next preceding,*" *&c., &c.*

Soil of a brownish-yellow ochre color; contains no gravel. Very few fine quartz grains.

No. 1753—"*Virgin Soil. Upland. From the farm of the Rev. A. Hopkins. Crow's Station, E., O. & N. R. R., nine miles from Owensboro. Collected by C. W. Beckham.*" *Coal measures.*

Soil of a brownish umber-grey color; contains no gravel nor fine quartz grains.

No. 1754—"*Surface Soil, from an old field about forty years in cultivation. Same locality as preceding. Substratum; sandstone. Collected by C. W. Beckham.*"

Soil of a dirty buff color; contains no gravel or fine silicious sand.

No. 1755—"*Subsoil of the next preceding,*" *&c. &c.*

Soil of a brownish-orange-buff color; contains no gravel or fine quartzose sand.

COMPOSITION OF THESE DAVIESS COUNTY SOILS, DRIED AT 212° F.

	No. 1750	No. 1751	No. 1752	No. 1753	No. 1754	No. 1755
Organic and volatile matters. . .	5.475	3.150	2.715	5.875	2.550	3.175.
Alumi'a and iron and mang. oxides	6.174	7.065	10.654	5.349	5.502	12.958.
Lime carbonate	.120	.245	.095	.220	.085	.075
Magnesia	.016	.034	.021	.044	.133	.080
Phosphoric acid	.141	.125	.061	.086	.083	.102
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.134	.053	.244	.407	.265	.474
Soda	.301	. . . .	. . . .	. . . .	. . . .	.075.
Sand and insoluble silicates . . .	86.605	88.390	85.415	86.590	90.890	81.300
Water expelled at 380° F.	.975	.925	.910	1.450	.600	1.175
Total	99.941	99.987	100.115	100.021	100.108	99.414
Hygroscopic moisture.	1.775	1.515	1.565	1.700	0.875	3.500.
Potash in the insoluble silicates .	.887	1.122	1.386	.975	1.396	1.457
Soda in the insoluble silicates . .	.581	.709	.680	.403	.729	.639.
Character of the soil	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

The comparative analyses of these soils show the usual influence of continued exhaustive culture in the diminution of some of their essential mineral ingredients. The soils are of full average natural fertility; the subsoils would doubtless benefit the surface, if gradually brought up in the cultivation, and organic matters supplied by the ameliorating influence of clover and other green crops wholly or partly plowed in. A considerable reserve of the alkalies is seen to be present in the insoluble silicates, which will add greatly to the durability of the soil; but, doubtless, the application of available phosphates, and the use of wood ashes, would be beneficial in increasing the productiveness of the old field soils.

No. 1756—"CLAY, *from the same locality; twenty feet from the railroad and ten feet below the surface of soil No.* 1754. *Below the coal at Dr. Hickman's Springs. The layer is about thirteen inches thick.*"

A sandy clay; generally of a light-grey color, with ferruginous infiltrations in the fissures, and some old obscure vegetable impressions. It contains about fifty per cent. of fine clear sand. It burns quite hard, and of a handsome light-salmon color, and hence may be quite valuable for *terra cotta* work or bricks or tiles.

The air-dried clay lost 1.500 per cent. of moisture at 212° F.; .005 per cent. of moisture at 380°, and 1.500 per cent. of combined water at the red heat. It would probably shrink less in the fire than most clays, but would not answer for a fire-clay.

COALS OF DAVIESS COUNTY.

No. 1757—"*Coal No. D? Montgomery's coal mine, about one and a half miles above Owensboro. Collected by C. J. Norwood.*"

A pure pitch-black coal. Has but little fibrous coal. Some thin scales of pyrites in the seams.

No. 1758—"*Coal D. Dutch mine, about one and a half miles above Owensboro. Average thickness about three feet. Average sample by C. J. Norwood.*"

A splint coal; some reedy fibrous coal between the laminæ, and much show of bright pyritous scales in the seams.

No. 1759—"*Coal D. Bon Harbor mines. Barrett's new bank. Average thickness four feet and a half. Sample by C. J. Norwood.*"

A splint coal, with much fibrous coal between the laminæ, and granular and bright lamellar pyrites. Iridescent on some of the seam faces.

No. 1760—"*Coal D. Dean's mine, about one and a half miles above Owensboro. Collected by C. J. Norwood.*"

Resembles the preceding.

No. 1761—"*Coal, from Duncan's bank. Richardson's property, Friendly Grove, near Knottsville. Collected by P. N. Moore.*"

Mostly splitting easily into thin laminæ, with considerable fibrous coal and some granular pyrites between. Some bright scales of pyrites in the seams.

COMPOSITION OF THESE DAVIESS COUNTY COALS, AIR-DRIED.

	No. 1757.	No. 1758.	No. 1759.	No. 1760.	No. 1761.
Specific gravity	1.323	1.340	1.318	1.337	1.285
Hygroscopic moisture	6.20	4.10	5.80	5.12	6.20
Volatile combustible matters	36.20	38.50	35.06	34.72	41.90
Coke	57.60	57.40	59.14	60.16	51.90
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	42.40	42.60	40.86	39.84	48.10
Carbon in the coke	50.90	51.00	50.40	51.44	47.40
Ash	6.70	6.40	8.74	8.72	4.50
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Light spongy.	Light spongy.	Light spongy.
Color of the ash	Lilac-grey.	Lilac-grey.	Light lilac-grey.	Light lilac-grey.	Grey-lilac.
Per centage of sulphur	1.519	1.538	3.985	3.513	3.743

EDMONSON COUNTY.

LIMONITE IRON ORES.

No. 1762—"*Ore, from Still-house Branch of Bear Creek. Average sample by P. N. Moore.*"

In irregular curved laminæ, of a deep brown color; frequently inclosing nuclei of softer yellowish and reddish ochreous ore.

No. 1763—"*Ore, from the south side of Dismal Creek, near Thomas Meredith's. Average sample by P. N. Moore.*"

Mostly in dense dark brown irregular curved laminæ, with some softer and lighter colored ore.

No. 1764—"*Ore, from the head of Sycamore Branch of Bear Creek. Average sample by P. N. Moore.*"

Much like the preceding.

No. 1765—"*Ore above the coal. Mill Branch of Bear Creek. Average sample by P. N. Moore.*"

In thin irregular laminæ, cellular in parts, of a brown color; mixed with yellowish-brown ochreous ore.

No. 1766—"*Limestone Ore. Jacob Snider's. Cane Branch of Gulf Creek. In the Chester Group. Cabinet specimen. Collected by P. N. Moore.*"

Mostly dense dark-colored ore, in carved laminæ or cellular masses, with some little brownish-ochreous softer ore.

COMPOSITION OF THESE EDMONSON COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1762.	No. 1763.	No. 1764.	No. 1765.	No. 1766.
Iron peroxide	40.798	47.724	49.906	32.820	77.871
Alumina	. . . . .	. . . . .	. . . . .	. .	1.444
Manganese oxide	1.293	2.501	3.330	2.356	not est.
Lime carbonate	a trace.	a trace.	a trace.	a trace.	a trace.
Magnesia	a trace.	a trace.	a trace.	a trace.	.070
Phosphoric acid	1.019	.697	.694	.984	.505
Sulphuric acid	.360	.315	.395	.285	a trace.
Combined water	7.250	8.250	9.320	8.330	11.050
Silica and insoluble silicates	50.030	41.145	36.780	55.180	8.660
Moisture and loss	. . . . .	. . . . .	. . . . .	.045	.400
Total	100.750	100.632	100.425	100.000	100.000
Per centage of iron	28.559	33.407	34.407	22.974	54.510
Per centage of phosphorus	.445	.304	.303	.430	.221
Per centage of sulphur	.207	.125	.158	.114	a trace.
Per centage of silica	46.760	39.560	33.460	48.960	8.660

With the exception of No. 1766, which is quite good and rich, these are rather poor, highly silicious ores, with a full amount of phosphorus, which might be profitably used with richer aluminous ores.

EDMONSON COUNTY CLAYS.

No. 1767—"*Silicious Clay, from Sowder's farm, near Green river. Chester Group. Bed four to six feet thick. Collected by John R. Procter.*"

In irregular lumps; friable; of an olive and brownish-grey color. Powder light grey.

No. 1768—"*Clay, from Sowder's farm, on Caney Branch, one mile from Green river. Bed seven to eight feet thick; in layers of various colors. Collected by John R. Procter.*"

(*a*) The upper or light-dove-colored layer.

(*b*) The second, light grey, nearly white layer.

(*c*) The third, grey layer.

(*d*) The lowest layer. Olive-grey, mottled with yellowish-grey.

COMPOSITION OF THESE EDMONSON COUNTY CLAYS, DRIED AT 212° F.

	No. 1767.	No. 1768 *a*.	No. 1768 *b*.	No. 1768 *c*.	No. 1768 *d*.
Silica	80.160	77.660	74.460	71.560	67.560
Alum'a and iron and mang. ox's	11.600	16.800	20.440	22.860	22.540
Lime carbonate	.760	.480	.640	.680	.980
Magnesia	.560	not est.	not est.	not est.	.671
Phosphoric acid	not est.	not est.	not est.	not est.	.025
Potash	3.854	1.002	not est.	not est.	2.470
Soda	.583	.484	not est.	not est.	.058
Water and undetermined	2.483	4.340	4.460	4.900	5.696
Total	100.000	100.766	100.000	100.000	100.000

While these clays would not prove very refractory in the fire, they may be made very useful for common pottery ware.

ESTILL COUNTY.

No. 1769—CLAY IRON-STONE. "*Carbonate ore, from Tubb's bank, near Estill Furnace. Has been weathered two years. Collected by P. N. Moore.*"

A granular carbonate ore, of various tints of grey, with more or less of limonite. In some parts somewhat oölitic.

COMPOSITION, DRIED AT 212° F.

Iron carbonate	76.491	= 39.758 per cent. of iron.
Iron peroxide	4.049	
Alumina	2.014	
Manganese carbonate	not est.	
Lime carbonate	5.400	
Magnesia carbonate	.514	
Phosphoric acid	.409	= 0.178 phosphorus.
Sulphuric acid	.267	= .107 sulphur.
Silicious residue	9.330	Containing 7.660 silica.
Undetermined and loss	1.526	
	100.000	

Quite a good ore of its kind.

ESTILL COUNTY LIMONITE ORES.

No. 1770—"*Ore, from Luster drift. Thacker Ridge. Railroad west of Fitchburg. Sample has been exposed to the weather for some time. Collected by P. N. Moore.*"

In irregular, dense, dark-colored, curved laminæ, with some soft ochreous ore between.

No. 1771—"*Limestone Ore. Logan Ridge. Estill Furnace. Has been weathered two years. Collected by P. N. Moore.*"

Resembles the preceding. Ochreous matter brownish.

No. 1772—"*Ore, from Tubb's bank. Estill Furnace. Has been weathered two years. Collected by P. N. Moore.*"

Resembles the preceding.

No. 1773—"*Ore, from Horse-ridge banks. Cottage Furnace. In sub-carboniferous limestone. Average sample from a pile of ore weathered more than a year. Collected by P. N. Moore.*"

Mostly in dense, dark-colored laminæ, irregularly curved or forming a cellular structure, with some whitish and light-brown softer material.

COMPOSITION OF THESE ESTILL COUNTY LIMONITES, DRIED AT 212° F.

	No. 1770.	No. 1771.	No. 1772.	No. 1773.
Iron peroxide	74.127	65.535	75.598	65.591
Alumina	3.542	2.798	1.971	5.762
Manganese oxide	not est.	not est.	not est.	not est.
Lime carbonate	.390	.450	.540	traces.
Magnesia	.461	1.073	.258	.248
Phosphoric acid	.601	.537	.601	.447
Sulphuric acid	not est.	not est.	not est.	traces.
Combined water	11.270	9.800	11.730	11.000
Silica and silicates	9.580	20.480	8.910	16.230
Moisture and loss	.029	. .	.392	.722
Total	100.000	100.673	100.000	100.000
Iron per centage	51.889	45.874	52.918	45.914
Phosphorus per centage	.262	.234	.262	.195
Sulphur per centage	not est.	not est.	not est.	traces.
Silica per centage	7.860	18.260	7.260	14.160

PIG IRONS OF ESTILL COUNTY.

No. 1774—"*No. 3 Cold-blast Charcoal Pig Iron. Red River Furnace. Fitchburg. Collected by P. N. Moore.*"

A moderately fine-grained, somewhat dark-colored iron. Yields to the file and extends a little under the hammer.

No. 1775—"*No. 5 Cold-blast Charcoal Pig Iron. Red River Furnace, &c. Collected by P. N. Moore.*"

A silvery-white iron. Hard, brittle; but the small fragments extend a little under the hammer.

No. 1776—"*Car-wheel Iron. No. 1 Cold-blast Charcoal Iron. Red River Iron Works, at Fitchburg. From G. S. Moore & Co., of Louisville.*"

A moderately coarse-grained, dark-grey iron. Yields with difficulty to the file; extends somewhat under the hammer.

No. 1777—"*Car-wheel Iron. No. 1 Cold-blast Charcoal Iron. Estill Furnace. From G. S. Moore & Co.*"

Resembles the preceding, but is somewhat coarser-grained, with some spots of finer-grained in the centre of the pig.

COMPOSITION OF THESE ESTILL FURNACE IRONS.

	No. 1774.	No. 1775.	No. 1776.	No. 1777.
Iron	93.728	93.963	94.174	92.582
Graphite	3.520	2.000	3.340	3.500
Combined carbon	.780	2.550	1.110	1.200
Manganese	.389	.181	not est.	not est.
Silicon	1.202	.363	.447	.960
Slag	.360	.320	.360	.360
Aluminum	.264	.648	not est.	not est.
Phosphorus	.290	.338	.402	.444
Sulphur	.080	.104	.182	.066
Undetermined and loss	.....	.....	.....	.888
Total	100.613	100.467	100.015	100.000
Total carbon	4.300	4.550	4.450	4.700
Specific gravity	7.168	not est.	7.226	7.272

The high character of these pig metals for producing tough malleable iron is well established.

FAYETTE COUNTY.

No. 1778—"PHOSPHATIC LIMESTONE. *Forming a thin layer in the Lower Silurian (Blue) limestone (Cincinnati Group?). McMeekin's quarry. Newtown Turnpike, about three miles north of Lexington. Said by the quarryman to be sometimes as much as a foot in thickness. Collected by R. Peter.*"

A somewhat friable rock of a bluish-grey color; brownish-grey on the weathered surfaces. Containing many microscopic marine univalve shells. Adheres strongly to the tongue.

COMPOSITION, DRIED AT 212° F.

Phosphoric acid, lime, magnesia, alumina, iron oxide	85.270
Fluoride of calcium	not est.
Carbonate of lime	9.180
Carbonate of magnesia	.371
Silica and insoluble silicates	4.780
Alkalies, organic matters, &c., not estimated	.399
Total	100.000

The phosphates in this limestone were found to contain as much as 31.815 per cent. of the weight of the rock of phosphoric acid, equal to 69.452 per cent. of tribasic phosphate of lime!

This remarkable rock, on a pile thrown out for turnpiking purposes, attracted the attention of the writer, while riding along the road. Although it has been long known that the friable layers of our "Blue limestone" are quite rich in phosphates, a fact which the writer brought to the attention of the agricultural public as early as April, 1849, in the Albany Cultivator, of New York, yet no one up to this time, as far as is known to him, has found any so rich in them as this.

The subject is worthy of further investigation, especially in view of the agricultural and commercial value of the phosphates for use as fertilizers. As is well known, the abundant phosphates of the rock substratum is one of the main causes of the great and durable fertility of our "blue grass soil," so-called, as well as of the superior development of the animals reared and nourished on its products.

SOILS OF FAYETTE COUNTY.

No. 1779—"*Virgin Soil, taken from one half inch to six inches below the surface. From woodland pasture, which has been grazed for about seventy years. On elevated ground, near the remains of the old earth-works of the mound-builders. (Described in Collins' History of Kentucky and elsewhere as on*

the farm of Col. Meridith, who was the earliest proprietor of the farm.) On the farm of R. Peter. Same as described in No. 27 in volume I, old series, Kentucky Geological Reports. On the Lower Silurian formation. Collected by B. D. Peter."

A rich grey-brown loam, containing a little fine-grained shot iron ore, and some small silicious particles. The bolting-cloth separated from the insoluble silicates, left after digestion of the soil in acids, a small portion of small roundish-whitish grains of partly decomposed silicates, but no pure quartz grains.

No. 1780—"*Subsoil of the preceding, taken from six to fourteen inches below the surface.*"

Soil rather more reddish than the surface soil. Contains, like that, a few small grains of shot iron ore and silicious particles. The bolting-cloth separated a rather larger quantity of small rounded grains of undecomposed silicates; some appearing as casts of minute globular shells.

No. 1781—"*Virgin Soil. Open pasture. J. H. Talbutt's farm ("The Meadows"), late Warfields; half a mile northeast of Lexington. From the top of a hill to the east of the house, heavily set with blue grass. Sample taken to the depth of sixteen inches. Primitive growth: black walnut, black, blue, and white ash, elm, hickories, oaks, sugar-tree, &c. Has been long cleared. Lower Silurian formation. Sample collected by John H. Talbutt.*"

Dried soil of an umber color; contains no gravel, but some little shot iron ore, &c.

No. 1782—"*Subsoil of the next preceding; taken to the depth of three feet from the surface,*" *&c., &c.*

No. 1783—"*Underlying clay of the same; taken at the depth of three feet below the surface. Contains shot iron ore, manganese oxide,*" *&c.*

Dried subsoil of a dirty light-brown color. The silicious residue contained a few small quartzose grains.

COMPOSITION OF THESE FAYETTE COUNTY SOILS, DRIED AT 212° F.

	No. 1779.	No. 1780.	No. 1781.	No. 1782.	No. 1783.
Organic and volatile matters . .	4.676	3.085	7.800	4.410	4.400
Alum'a and iron and mang. ox's	9.570	*10.445	12.286	14.427	19.921
Lime carbonate.	.230	.220	1.145	.545	.130
Magnesia	.140	.140	.394	.340	.376
Phosphoric acid	.444	.540	.364	.358	.364
Sulphuric acid	not est.	not est.	not est.	not est.	not est.
Potash	.287	.343	.735	.402	.755
Soda.	not est.	.192	.084	.301	. . . .
Sand and insoluble silicates . .	82.860	83.260	76.690	77.440	72.540
Water, expelled at 380° F. . . .	1.824	1.234	1.300	.925	1.200
Undetermined and loss	. . . . .	.541	. . . . .	.852	.314
Total	100.031	100.000	100.798	100.000	100.000
Hygroscopic moisture	2.165	1.965	2.975	3.135	3.525
Potash in the insoluble silicates.	1.274	1.314	.718	.910	.644
Soda in the insoluble silicates .	.211	.583	.200	.212	.167
Character of the soil	Woodland pasture.	Subsoil.	Virgin soil.	Subsoil.	Under clay.

*Containing: of alumina, 6.093; iron peroxide, 4.330; and manganese oxide, .020 per cent.

The analyses demonstrate the richness of these soils, more especially of Nos. 1781–'2–'3, which is shown in the small relative quantity of silicious residue, and the comparatively large proportions of phosphoric acid and potash, &c. Although they may not have been submitted to the plow, they yet cannot be considered virgin soils, having been for a long time grazed, and been thus altered in composition. The "Meadows" has been mostly cultivated as a stock farm, mainly for the raising of fine race-horses and improved cattle; and there is reason to believe, from the large proportion of potash in the soluble form in this pasture land, that it was improved rather than deteriorated by the feeding of the stock upon it: the loss by grazing being more than compensated by the additional food supplied to the animals, in winter as well as other times.

FLOYD COUNTY.

COALS.

No. 1784—"*Coal. Snipe's bank. Branch of Abbott's Creek. Average sample from the outcrop. About two feet shown. Collected by A. R. Crandall.*"

248

A pretty pure splint coal. Some fibrous coal and fine granular pyrites between the laminæ, and some external ferruginous stain.

No. 1785—"*Coal, from Harris' bank, on Muddy Creek, one mile from Prestonsburg. Forty-four inches thick. Average sample by A. R. Crandall.*"

A bright, pitch-black coal, with some bright pyritous scales, and but little fibrous coal. A somewhat hard coal.

No. 1786—"*Coal. Jas. H. Hatcher's bank. Mouth of Abbott's Creek. Bed forty-two to forty-six inches thick. Average sample by A. R. Crandall.*"

A bright-looking, somewhat firm coal, with very little fibrous coal or pyrites.

COMPOSITION OF THESE FLOYD COUNTY COALS, AIR-DRIED.

	No. 1784.	No. 1785.	No. 1786.
Specific gravity	1.289	1.274	1.307
Hygroscopic moisture	3.20	2.50	2.50
Volatile combustible matters	38.80	40 80	38.56
Coke	58.00	56.70	58.94
Total	100.00	100.00	100.00
Total vola ile matters	42.00	41.30	41.06
Fixed carbon in the coke	55.04	56.70	53.44
Ash	2.96	3.24	5.50
Total	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Light spongy.
Color of the ash	Light chocolate.	Light brownish.	Light lilac-grey.
Percentage of sulphur	1.289	1.895	1.915

These are all remarkably pure and good coals. Their small ash per centage corresponds nearly with their low specific

gravity. Their proportion of sulphur is also moderate. Their large yield of volatile combustible matters, and their spongy coke, may make them profitably available for use in the gas-works. Doubtless they will be found very good for the smelting and manufacture of iron.

GRAYSON COUNTY.

COAL.

No. 1787—"*Coal, from the South or Allen bank, near the Falls of Rough Creek. Two feet thick. Collected by P. N. Moore.*"

A pure-looking coal, breaking easily, with a shining pitch-like appearance, and an irregular, so-called, bird's-eye fracture. Has very little fibrous coal and no apparent pyrites, except some fine granular.

COMPOSITION, AIR-DRIED.

Specific gravity	1.343		
Hygroscopic moisture	6.50	Total volatile matters	36.54
Volatile combustible matters	30.04		
Coke (quite dense)	63.46	Carbon in the coke	55.54
		Light lilac-grey ash	7.92
	100.00		100.00
Per centage of sulphur	1.972		

FERRUGINOUS AND MARLY CLAYS OF GRAYSON COUNTY.

No. 1788—"*Ferruginous Clay. Nodular. Below the upper limestone. Hat Branch of Bear Creek. Three and a half to four feet thick.*"

Of a handsome chocolate-brown color. Not adhering much to the tongue. Powder of a handsome grey-chocolate color.

No. 1789—"*Nodular Ferruginous Clay. Canolaway Creek.*"

Resembles the preceding.

No. 1790—"*Marly Shale, found below the limestone. Hat Branch of Bear Creek. Four feet thick. Collected by John R. Procter.*"

Breaking easily when dry. Of a greyish-olive-green color, with some parts brownish. Not adhering much to the tongue. Powder of a handsome greenish-grey color.

No. 1791—"*Marly Shale. Haycraft's Lick. Similar to preceding.*"

Of a dark olive-grey color when dry.

No. 1792—"*Red Marly Shale, same locality, &c., mixed with the preceding in the sample.*"

Of a chocolate brown color.

No. 1793—"*Brown Marly Clay. Cedar Knob Lick.*"

Of a dark reddish-brown or chocolate color when dry. Conglomeratic, with fragment of material similar to No. 1792.

COMPOSITION OF THESE GRAYSON COUNTY FERRUGINOUS AND MARLY CLAYS AND SHALES, DRIED AT 212° F.

	No. 1788.	No. 1789.	No. 1790	No. 1791	No. 1792	No. 1793
Alumina . . . . . Iron and manganese oxides	14.451	*b*12.282 *c*7.588	26.221	27.811	25.758	23.071
Lime carbonate	1.160	1.380	9.160	.880	1.580	1.180
Magnesia	1.715	1.643	6.629	.824	4.437	.497
Phosphoric acid	1.089	see *b*.	1.089	.109	.102	.089
Potash (Total, obtained by fusion; includes insoluble silicates.)	4.240	5.049	4.944	5.554	5.145	4.093
Soda (Total, obtained by fusion; includes insoluble silicates.)	.948	1.060	1.061	.657	.347	.438
Silica and insoluble silicates .	74.360	*d*68.380	44.760	59.920	58.960	60.760
Water expelled at red heat, &c.	7.000	8.250	6.136	4.245	3.671	9.872
Total	*a*104.963	*a*105.632	100.000	100.000	100.000	100.000

(*a*) The apparent excess is due to the alkalies in the insoluble silicates, which are estimated also in the *total* alkalies given above.
(*b*) Including phosphoric acid and manganese oxide, not separately estimated.
(*c*) Iron peroxide.
(*d*) Containing of silica: 51.020; of alumina, iron and manganese oxides, and phosphoric acid, 14.330.

These ferruginous and marly shales and clays, when of a good color, may be termed mineral paints, and be very profitably used in that way; but, in consequence of their large proportions of alkalies, especially of potash, as well as of phosphoric acid, they promise to be quite valuable, applied as top dressing, for renewing old worn-out tobacco soil. As they are found in enormous quantities over a very great extent of country, the best method of making them profitably available is matter of great interest.

Chemical analyses show that, while a portion of their alkaline constituents is soluble in acids, the larger part of them is locked up in the insoluble silicates. Spread upon the soil,

therefore, without admixture or preparation, their ameliorating influence would probably result more from their large proportion of the elements of clay, giving the soil more consistence, and increasing its power of absorbing atmospheric agencies, &c., than from the alkalies or phosphoric acid, &c., they contain. In short, the application of these marls to the surface might be like the plowing up of a subsoil, rich in the mineral elements of plant food, but poor in the organic compounds which help to bring them into a soluble and available state.

Exposed to the atmospheric agencies, however, the insoluble silicates undergo a gradual, slow decomposition, and their valuable ingredients are thus set free for the use of plants. The decomposing remains of vegetables accelerate this process, and hence the great propriety of using these marls together with stable manure or other organic fertilizers, or of employing a clover or other green crop, plowed in, as a means of distintegrating the silicates. Doubtless poor exhausted land, which had been top-dressed with the marl, and then sowed in clover, which, after the growth of one or two seasons, was plowed in, would be found to be greatly improved in fertility. A similar result, in some degree, might possibly be obtained, in a single season, by the use of buckwheat, plowed in at maturity.

A quicker mode of setting free the alkalies, &c., of these marls, would necessarily be more expensive. The process used in the chemical analysis, viz: that of heating, to a moderate red heat, the mixture of the finely-ground marl with a large proportion of pulverized carbonate of lime, and about an equal proportion of sal ammoniac (ammonium chloride), is quite effectual in separating all the alkalies of the insoluble silicates. But it is somewhat expensive on a large scale. In this process the mutual reaction of the carbonate of lime and sal ammoniac produces carbonate of ammonia, which evaporates and is lost, and calcium chloride, which, together with the excess of carbonate of lime present (calcined in the process partly into caustic lime), cause the decomposition of the

silicates, and set free the alkalies. Calcium chloride and carbonate of lime, then, are the essential decomposing agents in this process; and as calcium chloride is present in the bittern water of all salt-works, and frequently thrown away as a waste product in other manufactories, or may be cheaply made by the application of hydrochloric acid to limestone, this process would be much more economical than that of the use of the ammonia salt. Under the head of Clay county, in the present volume, are some remarks on the proposition to use the bittern water of salt-works for this purpose—an application of this waste product, which is yet more promising, from the fact that this water contains potash and other salts, which may also be valuable on the exhausted soil.*

But, for the decomposition of the marl, not only must it be brought into a plastic state or be powdered, but the limestone or lime, with which it is to be mixed, must also be in the form of powder, so that they may be intimately mixed together and fully incorporated with the calcium chloride. With a cheap power and a good mill this might not be very expensive. In order to calcine the mixture, the plastic mass, produced by working up together the marl, lime, and solution of calcium chloride, should be made up into lumps or brick-like masses, dried to a certain extent, and then calcined at a moderate red heat, not sufficient to fuse them. The time during which they should be maintained at a red heat need not exceed a few hours.

Other modes might be available; as by the use of chlorine gas, which, if the lumps of the marl are porous, would not necessitate pulverization. This gas is to be cheaply obtained from the low-priced hydrochloric acid and oxide of manganese mixed, and if it be allowed to pass slowly from above through the marl lumps contained in a tall, tight cylindrical receptacle, would exert considerable decomposing influence upon the sil-

* It is generally believed that magnesium chloride is injurious to vegetation. As this is present in the bittern water, careful experiments to test its utility would be necessary. But the magnesium chloride would be decomposed by the lime in the process of calcination, and the free magnesia thus separated would not probably be injurious, notwithstanding the long-standing prejudice against this earth.

icates. This process would doubtless be at least as expensive as the above named.

The mere mixture of slacked lime with the powdered marl, when applied to the land, would doubtless be beneficial in accelerating its decomposition, and calcining them together at a moderate red heat might be yet more useful, especially if a little common salt be added. Indeed, merely calcining the clay alone, if the heat is not sufficient to fuse it, seems to set some of its alkaline constituents free; and hence, probably, one reason of the improvement of old soil by the English practice of paring and burning it. In numerous cases the writer has found the insoluble silicates to become more decomposable by the action of the acids after ignition.*

No. 1794—"LIMONITE IRON ORE, *containing clay iron-stone. Old Nolin Furnace property, three and a half miles north of Bee Spring. West of the road at the head of one of the forks of Decker Branch. On the road near the Brownsville and Grayson Springs road. Average sample by P. N. Moore.*"

Generally soft and porous, of a brownish-yellow color, with denser and darker colored irregular laminæ, and some nodules or portions of bluish-grey, fine granular clay iron-stone, which is somewhat oölitic, with small whitish particles.

COMPOSITION, DRIED AT 212° F.

Iron peroxide	48.913	= 36.526 iron.	
Iron carbonate	5.735		
Alumina	7.125		
Lime carbonate	9.410		
Magnesia carbonate	.144		
Phosphoric acid	.489	=	.209 phosphorus.
Sulphuric acid	.199	=	.080 sulphur.
Combined water and loss	8.905		
Silica and insoluble silicates	19.080	Containing 16.760 silica.	
	100.000		

A good and sufficiently rich ore, with but a moderate proportion of phosphorus, likely to yield a good quality of iron, if properly smelted. It contains nearly ten per cent. of carbonate of lime, which will aid in fluxing it.

*The simultaneous use of the marl and slacked lime as a top-dressing on a clover crop, or as a preparation for a crop of clover, which is subsequently plowed under, would no doubt be quite ameliorating to the soil.

GREENUP COUNTY.

COALS.

No. 1795—"*Coal, from Turkey Lick bed, on Turkey Lick. Collected by A. R. Crandall.*"

A splint coal. Some parts seemingly quite pure, with but little fibrous coal; other portions in thin shaly layers, with granular pyrites in the fibrous coal.

No. 1796—"*Coal* 3. *Turkey Lick Coal. Pennsylvania Furnace. Average sample from the lower and middle parts of the coal.*"

A splint coal, separating into thin laminæ, with fibrous coal and fine granular pyrites between.

No. 1797—"*Coal, from Turkey Lick coal mines. Main entry. One hundred and eighty feet from the outcrop. Average sample taken at that spot. By A. R. Crandall.*"

A splint coal, pretty pure looking, but has some fine granular pyrites in the fibrous coal between its thin laminæ.

No. 1798—"*Turkey Lick Coal. Old entry. Hunnewell. Average sample by A R. Crandall.*"

Like the preceding, but having less of the thinly laminated portion, with fibrous coal and granular pyrites between.

No. 1799—"*Coal. Raccoon Furnace. Average sample by A. R. Crandall.*"

A splint coal, splitting into quite thin laminæ, with much light fibrous coal and some fine granular pyrites between them.

No. 1800—"*Coke, from Coal No.* 3. *Turkey Lick coal. Hunnewell Furnace. Collected by A. R. Crandall.*"

A bright spongy coke.

COMPOSITION OF THESE GREENUP COUNTY COALS AND COKE, AIR-DRIED.

	No. 1795.	No. 1796.	No. 1797.	No. 1798.	No. 1799.	No. 1800.
Specific gravity	1.347	1.331	1.280	1.332	1.384	.....
Hygroscopic moisture	4.24	4.00	4.56	4.60	4.22	19.20
Volatile combustible matters	34.76	37 70	36 68	34.80	30.10	
Coke	61 00	58.30	58.76	60.60	65.68	80.80
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	39.00	41.70	41.24	39.40	34.32	19.20
Carbon in the coke	48.70	51.60	52.40	51.00	53.68	75.10
Ash	12.30	6.70	6.36	9.60	12.00	5.70
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Dense spongy.	Light spongy.	Dense spongy.	Friable.	.....
Color of the ash	Light lilac-grey.	Lilac-grey	Very light lilac-grey.	Very light lilac-grey.	Light lilac-grey.	Nearly white.
Per centage of sulphur	1.601	2.645	0.682	0 667	0.925	0.666

By comparing the sulphur per centage in No. 1796, and in the coke made from it, No. 188, it will be seen that more than three fourths of the sulphur of the coal appears to be removed in the process of coking. But the smaller ash per centage in this coke seems to indicate that a purer sample of this coal was used in its manufacture.

GREENUP COUNTY PIG IRONS.

No. 1801—"*Pig Iron. No.* 1 *Foundry iron. Hunnewell Furnace.*"

Quite a coarse-grained, light-grey iron. Somewhat hard, but yields to the file.

No. 1802—"*Pig Iron. No.* 1 *hot-blast silver-grey or glazed pig. Pennsylvania Furnace.*"

Moderately fine granular; whitish. Yields to the file and extends very little under the hammer. Quite brittle.

No. 1803—"*No.* 1 *Foundry Iron. Pennsylvania Furnace.*"

Coarser grained and darker than the preceding. Yields to the file; extends a little under the hammer.

No. 1804—"*Mill Iron. Pennsylvania Furnace.*"

Finer grained, darker, and more dull than the preceding. Extends considerably under the hammer.

No. 1805—"*No. 2 Foundry Iron. Pennsylvania Furnace.*"

Moderately fine-grained. Yields to the file; extends but little under the hammer.

No. 1806—"*No. 2 Cold-blast Iron; made from blue ore alone. Laurel Furnace. Collected by P. N. Moore.*"

A dark-grey, fine-grained iron. Extends somewhat under the hammer, but is brittle.

No. 1807—"*Mill Iron. Hot-blast. Third casting with stone-coal. Raccoon Furnace. Collected by P. N. Moore.*"

A fine granular iron. Yields to the file, and extends somewhat under the hammer.

COMPOSITION OF THESE GREENUP COUNTY PIG IRONS.

	No. 1801	No. 1802	No. 1803	No. 1804	No. 1805	No. 1806	No. 1807
Specific gravity	. . .	. . . .	. . . .	. . . .	. . . .	6.680	6.927
Iron	92.284	90.630	92.060	94.764	92.856	92.697	91.596
Graphite	2.960	2.500	2.700	2.900	3.230	2.100	2.900
Combined carbon	.690	.830	.630	.780	. . . .	1.000	.250
Silicon	3.011	4.969	3.104	1.193	2.545	1.813	3.477
Slag	.880	.360	.300	.200	.360	not est.	.800
Phosphorus	.474	.741	.710	.860	.817	.454	.247
Sulphur	not est.	.040	.033	.033	.046	.218	.237
Undetermined and loss	. . . .	. . . .	.463	. . . .	.146	1.718	.493
Total	100.299	100.070	100.000	100.730	100.000	100.000	100.000
Total carbon	3.650	3.330	3.330	3.680	3.230	3.100	3.150

While the total quantity of carbon in these pig irons does not vary much, there is a considerable difference in the proportions of silicon and phosphorus, both of which tend to make the iron brittle in the cold. The condition of the carbon, whether it be in the state of graphite or in combination

with the iron, makes a great difference in the quality of the metal, as is well known.

The cold-blast iron, No. 1806, made mostly from the "blue ore" (clay iron-stone), seems to contain nearly as much sulphur as the hot-blast iron, No. 1807, made with stone coal. The label does not state what was the character of the fuel used to smelt the former.

No. 1808—"IRON FURNACE SLAG, *from Raccoon Furnace, Green-up county. 'Mine-fall cinder,' with which little iron is made, but much slag. Collected by A. R. Crandall.*"

Of a dark bottle-green color; nearly black in the mass; transparent in the thin edges. Quite fusible, without intumescence, before the blow-pipe.

SPECIFIC GRAVITY = 2.868.

COMPOSITION.

Silica	47.960	Containing of oxygen.		24.902
Alumina	18.841		8.807	
Lime	20.462		5.819	
Magnesia	1.354		.451	
Iron protoxide	8.489	= 6.062 iron	1.887	
Manganese protoxide	not est.			
Phosphoric acid	.127	= .055 phosphorus.		
Sulphuric acid	.192	= .077 sulphur.		
Potash	2.045		.347	
Soda	.405		.104	
Loss	.125		17.415	24.902
Total	100.000			

The proportion of oxygen in the *bases* to that in the *silica* is as 1 : 1.423 in this slag, and as the proportions in a good slag are about as 1 : 2, it is evident that too little lime has been used in the flux, and that consequently a large proportion of iron oxide has formed glass with the excess of silicious matter, causing a serious loss. This cinder contains quite a considerable proportion of alumina, which seems to have carried with it more than the usual quantity of phosphoric acid into the cinder. The fact that the iron furnace slag may contain this injurious ingredient, and that probably alumina, lime in sufficient quantity being present, might be more instrumental

than any other material in the flux in removing it from the ore in the smelting furnace, contrary to the prevalent belief, was pointed out by the writer in volume 4th of the first series of Kentucky Geological Reports, page 44.

SOILS OF GREENUP COUNTY.

No. 1809—"*Virgin Soil. Woods. Sample taken to six inches below the surface. Top of a hill (ridge), eight feet above bed of coal. White Oak Creek, near Kenton Furnace. Collected by J. A. Monroe.*"

Dried soil of a brownish-grey color, mostly in friable lumps. Contains some fragments of ferruginous sandstone, and no quartz sand.

No. 1810—"*Subsoil to the preceding, taken eighteen inches below the surface. By J. A. Monroe.*"

Dried soil somewhat lighter colored than the preceding. Contains more ferruginous sandstone fragments, and some small hollow nodules of limonite ore. The bolting-cloth separated from the silicious residue a few minute quartzose particles.

No. 1811—"*Surface Soil to the depth of six inches, from a corn field which has been in cultivation ten years. Valley of White Oak Creek. About ten feet above the bed of the creek. Collected by J. A. Monroe.*"

Soil of a light umber-grey color, mostly in friable lumps. The silicious residue contained a few small rounded grains of hyaline quartz.

No. 1812—"*Subsoil to the preceding, taken at eighteen inches below the surface. J. A. Monroe.*"

Subsoil of a light umber-grey color, slightly darker than the preceding. Contains fragments of brownish ferruginous sandstone.

COMPOSITION OF THESE GREENUP COUNTY SOILS, DRIED AT 212° F.

	No. 1809	No. 1810	No. 1811	No. 1812
Organic and volatile matters	5.590	5.600	4.375	3.790
Alumina and iron and manganese oxides	12.357	15.693	7.060	6.656
Lime carbonate	.645	.070	.270	.745
Magnesia	.366	.375	.083	.067
Phosphoric acid	.083	.147	.115	.109
Sulphuric acid	.003	a trace.	.027	.033
Potash	.433	.474	.098	.193
Soda	.023	.305	.068	.163
Soluble silica	.130	.095	.080	.135
Sand and insoluble silicates	79 500	76.060	86.890	87.665
Water, expelled at 388° F.	1.250	.950	1.100	.910
Loss	.220	.231	. . . .	. . . .
Total	100.000	100.000	100.166	100.466
Hygroscopic moisture	1.900	2.235	1.150	1.000
Potash in the insoluble silicates	2.301	2.829	1.220	0.817
Soda in the insoluble silicates	.509	.368	.520	.380
Character of the soil	Virgin woodla'd	Subsoil.	Cultivated field.	Subsoil.

As is frequently the case, there is great variety in the character of these coal-measure soils; those from the hill-top being quite rich, while the others from the valley are much less fertile: anomalous differences, evidently attributable to the original sources whence the soils were derived, or to the action of drainage waters, or other causes not known to us.

HANCOCK COUNTY.

COALS.

No. 1813—"*Cannel Coal. Cloverport Oil Company's mines, about eight miles south of Cloverport. Entry No.* 12, *at main breast. Base of the coal measures. Average sample by C. J. Norwood. Average thickness of the coal two and a half feet. It varies from twenty-two to thirty-six inches.*"

A dull-looking, very tough cannel coal. Has no marked appearance of pyrites.

No. 1814—"*Coal, from Hancock Coal Company's mines, below Hawesville. (Owned by the American Cannel Coal Company.) Collected by P. N. Moore.*"

Quite a pure-looking, firm, pitch-black coal. Has some little bright pyritous scales and fine granular pyrites between the laminæ.

No. 1815—"*Coal, from Milton Lawson's bank. Lead Creek, three miles from Hawesville. Average sample by P. N. Moore.*"

A splint coal, splitting into thin laminæ, with considerable fibrous coal and some granular pyrites between. Some external ferruginous stain. Has the appearance of having been weathered.

No. 1816—"*Coal, from Robt. Estes' bank. Back of Lewisport. Sample by P. N. Moore.*"

A pitch-black, rather firm coal, not all breaking into thin laminæ. Has much fibrous coal and granular and lamellar pyrites.

No. 1817—"*Coal, from James Mason's bank, between Hawesville and Lewisport. Sample by P. N. Moore.*"

Generally pitch-black and glossy—partly dull—on the cross fracture. Not generally breaking into thin laminæ. Has not much fibrous coal, but considerable appearance of granular pyrites, and some external ferruginous incrustation.

No. 1818—"*Coal, from Colbert's bank, near Lewisport. Sample by P. N. Moore.*"

A firm, pitch-black, glossy coal. Not much fibrous coal, but considerable shining pyritous scales and granular pyrites. Does not all split into thin laminæ.

No. 1819—"*Coal, from Bergenroth's bank, near old Reverdy mines. Sample by P. N. Moore.*"

A firm coal, not all breaking into thin laminæ. Has considerable fibrous coal between the laminæ, and some granular pyrites and external ferruginous stain.

No. 1820—"*Coal, from John C. Schafer's bank. Blackford Creek. Sample by P. N. Moore.*"

A pitch-black, firm, glossy coal. Considerable fibrous coal between some of the laminæ, and a few thin shining pyritous scales in the seams.

No. 1821—"*Coal, from the Breidenback bank. Lead Creek. Sample by P. N. Moore.*"

Generally glossy pitch-black, with some dull, thin laminæ, having fibrous coal between, and visible pyritous scales and granular pyrites.

No. 1822—"*Coal, from the Davidson bank, near Hawesville. Sample by P. N. Moore.*"

Appears to be a weathered specimen, having considerable ferruginous stain. Otherwise resembling the preceding.

No. 1823—"*Coal, from R. S. Lanum's bank, near Hawesville. Sample by P. N. Moore.*"

Resembles No. 1821.

COMPOSITION OF THESE HANCOCK COUNTY COALS, AIR-DRIED.

	No. 1813.	No. 1814.	No. 1815.	No. 1816.	No. 1817.	No. 1818.	No. 1819.	No. 1820.	No. 1821.	No. 1822.	No. 1823.
Specific gravity	1.213	1.357	1.353	1.323	1.289	1.401	1.336	1.308	1.292	1.268	1.298
Hygroscopic moisture	1.30	5.12	5.40	3.50	4 80	4.50	5.20	7.46	5.10	3.30	6.00
Volatile combustible matters	59.60	36.28	34.80	43.40	38.90	37.60	38.70	33 14	41.20	39.00	37.80
Coke	39.10	58.60	59.80	53.10	56.30	57.90	56.10	59.40	53.70	57.70	56.20
Total	100.00	100.00	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	60.90	41.40	40.20	46.90	43.70	42.10	43.90	40.60	46.30	42.30	43.80
Fixed carbon in the coke	27.00	47.60	49.30	45.56	50.06	47.46	48.50	55.20	46.60	50.50	48.70
Ash	12 10	11.00	10.50	7.54	6.24	10.44	7.60	4.20	7.10	7.20	7.50
Total	100.00	100 00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100 00	100.00
Character of the coke	Dense friable.	Dense.	Spongy.	Light spongy.	Light spongy.	Dense spongy.	Dense spongy.	Dense spongy.	Light spongy.	Light spongy	Spongy.
Color of the ash	Light gr.-brown.	Lilac-grey	Light brownish-grey.	Purplish-chocolate.	Light brownish-grey.	Light chocolate	Light lilac-grey.	Light grey	Light lilac-grey.	Brownish-grey.	Greyish-lilac.
Per centage of sulphur	1.890	4.038	2.398	4.155	2.316	7.809	2.266	1.368	3.331	3.373	3.180

Coal No. 1813, from the Cloverport Oil Company's mines, is remarkable for the large proportion of volatile combustible matters it yields.

HARLAN COUNTY.

COALS.

No. 1824—"*Cannel Coal or Bituminous Shale, from Long Branch of Martin's Fork. Average sample of the weathered outcrop by P. N. Moore. Bed thirty-eight inches thick.*"

A dull-black, tough cannel coal. Fracture large conchoidal, somewhat in layers. Some ferruginous and earthy incrustation.

No. 1825—"*Coal, from J. C. Howard's bank. Clover Fork of Cumberland river, one mile above Mount Pleasant. Sample by P. N. Moore from near the limited outcrop. Bed four and a half feet thick.*"

A bright, pitch-black coal (semi-bituminous), having very little fibrous coal, and no visible pyrites.

No. 1826—"*Coal, from Martin's Fork, Skidmore Creek. Taken from near the outcrop, by A. R. Crandall. Bed forty-two inches thick.*"

A much weathered sample, containing much powdered coal.

COMPOSITION OF THESE HARLAN COUNTY COALS, AIR-DRIED.

	No. 1824.	No. 1825.	No. 1826.
Specific gravity	1.510	1.289	1.356
Hygroscopic moisture	1.40	1.70	5.20
Volatile combustible matters	34.60	35.70	31.26
Coke	64.00	62.60	63.54
Total	100.00	100.00	100.00
Total volatile matters	36.00	37.40	36.46
Fixed carbon in the coke	39.40	59.60	60.08
Ash	24.60	3.00	3.46
Total	100.00	100.00	100.00
Character of the coke	Dense.	Very light spongy.	Pulverulent.
Color of the ash	Chocolate.	Light buff.	Light buff.
Per centage of sulphur	1.271	0.750	0.618

No. 1824 contains a very large proportion of earthy matter, and might probably be considered bituminous shale. This, however, does not prevent it from yielding even more volatile combustible matters than 1826, and nearly as much as 1825. Its specific gravity is correspondingly high. The other coals yield less than the average quantity of ash, and give a large proportion of coke, and are superior coals, especially for the manufacture of iron, &c.

HENRY COUNTY.

No. 1827—"METALLIC LEAD, *from the 'Silver and Spar Mines,' three miles below Lockport, in the Lower Silurian. Collected by C. J. Norwood.*"

Brought to the laboratory to be examined for silver. On a careful analysis, by the wet way, no evidence of the presence of that metal was found, although more than fourteen grammes were examined.

No. 1828—"LIMESTONE, *Lower Silurian, from the same locality as the above. Collected by C. J. Norwood.*"

A fossiliferous, coarse granular limestone, of grey and buff colors, containing more or less calc. spar, and having small irregular cavities lined with ochreous iron oxide.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	95.770
Magnesia carbonate	1.378
Alumina and iron and manganese oxides, and phosphoric acid	1.060
Sulphuric acid, alkalies, &c.	undeter'ed
Insoluble silicates	.980
Total	99.188

A good limestone, containing 53.631 per cent. of lime.

HOPKINS COUNTY.

COALS.

No. 1829—"*Coal D, from Diamond coal mine, about three quarters of a mile south of Earlington. (St. L. & S. E. R. R.) Average sample from along the entry, by C. J. Norwood.*"

A splint coal. Outer surfaces of most of the lumps somewhat soiled with dirt.

No. 1830—"*Coal D, from Saint Bernard coal mines, near Earlington. Upper drift. Bed three to four and a half feet thick. Average sample by C. J. Norwood.*"

A deep black, glossy splint coal, with but little fibrous coal between the laminæ, and no appearance of pyrites. Some thin plates of gypsum in the seams.

No. 1831—"*Coal B, from Fleming coal mine, one mile below Earlington. Bottom part two feet thick. Sample by C. J. Norwood.*"

A pitch-black, glossy coal. Some fibrous coal and fine granular pyrites between some of the laminæ, and bright pyritous and lime sulphate scales in some of the seams.

No. 1832—"*Coal B; same locality as the preceding. Top portion; four feet thick. Collected by C. J. Norwood.*"

Resembles the preceding.

No. 1833—"*Coal B, from Hecla coal mines. St. L. & S. E. R. R., near Earlington. Average sample by C. J. Norwood.*"

A pitch-black, glossy coal. But little fibrous coal between the laminæ. The sample has some thin scales of gypsum in some of the seams, and has some fragments in it of a thin pyritous shaly parting.

No. 1834—"*Coal B. Hecla mines, near Earlington. Average sample from the lower bench; about two feet four inches thick. By C. J. Norwood.*"

Resembles the preceding.

No. 1835—"*Coal B. St. Bernard coal mines, near Earlington. Lower drift. Average sample from the upper member; four feet thick. By C. J. Norwood.*" (*See also* 1830.)

Resembles No. 1830. Has some scaly incrustations of lime sulphate.

No. 1836—"*Coal D, from Hecla coal mines. Earlington. Carefully sampled by C. J. Norwood.*

A pitch-black coal. Very little fibrous coal. Some scales of lime sulphate, stained with iron oxide, in the seams, with some little shining pyrites.

COMPOSITION OF THESE HOPKINS COUNTY COALS, AIR-DRIED.

	No. 1829.	No. 1830.	No. 1831.	No. 1832.	No. 1833.	No. 1834.	No. 1835.	No. 1836.
Specific gravity	1.351	1.337	1.366	1.290	1.323	1.326	1.326	1.331
Hygroscopic moisture	5.00	4.30	3.04	2.70	3.28	3.82	3.20	2.32
Volatile combustible matters	35.26	37.64	36.90	40.74	39.32	36.38	38.30	37.68
Coke	59.74	58.06	60.06	56.56	57.40	59.80	58.50	60.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.26	41.94	39.94	43.44	42.60	40.20	41.50	40.00
Fixed carbon in the coke	49.24	50.56	49.06	51.64	49.54	51.10	48.50	51.00
Ash	10.50	7.50	11.00	4.92	7.86	8.70	10.00	9.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	*Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.
Color of the ash	Brownish-grey.	Dark brownish-grey.	Lilac-grey.	Light lilac-grey.	Lilac-grey.	Lilac-grey.	Lilac-grey.	Lilac-grey.
Per centage of sulphur	3.015	2.892	5.955	1.502	4.710	3.639	3.345	3.606

*Lt. sp. — Light spongy.

All of them good coals, although some few of them exceed the average per centage in ash and sulphur.

HOPKINS COUNTY SOILS.

No. 1837—"*Virgin Soil, from woods, at Harrison Station, L. & S. E. R. R., about thirty miles from Henderson. Forest growth: white and red oaks, hickories, &c. Geological formation above the sandstone. Collected by C. W. Beckham.*"

Dried soil of an umber-grey color; contains a very little ferruginous gravel. The silicious residue all passed through the bolting-cloth.

No. 1838—"*Surface soil, from a field twenty years in cultivation in corn and tobacco; adjoining the locality of the preceding soil,*" *&c., &c.*

Color of the soil like that of the preceding. It contains no gravel nor fine silicious sand.

No. 1839—"*Subsoil of the next preceding,*" *&c., &c.*

Dried subsoil of a brownish-buff color; contains no gravel nor fine silicious sand.

No. 1840—"*Virgin Soil, from woods. Farm of J. D. Morton. Morton's Gap. St. L. & S. E. R. R. Forest growth: dogwood, sweet gum, white oak, &c., &c. Substratum sandstone. Collected by C. W. Beckham.*"

No. 1841—"*Surface Soil, from an old field fifty years in cultivation; next adjoining the preceding locality. Field said to have been once exhausted and overgrown with sassafras, black jack, elm, &c. Has been cleared again, and is now in tobacco. It has been most of the time in red-top meadow. Collected by C. W. Beckham.*"

Contains no gravel or fine silicious sand.

No. 1842—"*Subsoil of the next preceding,*" *&c., &c.*

Contains no gravel or sand.

No. 1843—"*Virgin Soil, from the farm of John Wilson, near Nortonsville. St. L. & S. E. R. R. Underlying rock sandstone. Collected by C. W. Beckham.*"

Contains no gravel, but the bolting-cloth separated from the silicious residue a considerable quantity of clear quartz grains, rounded and angular.

No. 1844—"*Surface soil, from an old field fifty years in cultivation; now overgrown with blackberry, sumach, &c., &c. Same locality as preceding,*" *&c., &c.*

Contains no gravel, but a considerable proportion of fine clear quartz grains, rounded and angular.

No. 1845—"*Subsoil of the next preceding,*" *&c., &c.*

Like the preceding, contains fine quartz grains.

COMPOSITION OF THESE HOPKINS COUNTY SOILS, DRIED AT 212° F.

	No. 1837	No. 1838	No. 1839	No. 1840	No. 1841	No. 1842	No. 1843	No. 1844	No. 1845
Organic and volatile matters	3.950	3.900	3.100	5.895	4.000	3.080	7.125	3.185	3.815
Alumina and iron and manganese oxides	5.845	5.936	10.321	5.649	6.153	7.224	6.322	5.155	10.090
Lime carbonate	.125	.235	.115	.385	.245	.245	.395	.120	.145
Magnesia	.088	.137	.035	.142	.092	.095	.162	.124	.269
Phosphoric acid	.080	.099	.004	.061	.032	.061	.163	.080	.045
Potash	.193	.086	.354	.348	.300	.498	.325	.292	.518
Soda	....	.145	....	.103	.213	.235	.020	.186	.251
Water, expelled at 380° F.	1.375	1.150	1.050	.625	.420	.550	.875	.430	.685
Sand and insoluble silicates	88.015	88.115	84.665	86.590	89.195	88.415	85.200	91.455	85.160
Total	99.671	99.803	99.704	99.798	100.650	100.403	100.587	101.027	100.978
Hygroscopic moisture	1.750	1.600	2.600	1.580	1.225	1.335	1.775	0.730	2.160
Potash in the insoluble silicates	1.686	1.528	1.149	1.336	1.272	1.230	1.152	1.163	1.247
Soda in the insoluble silicates	.425	.371	.621	.604	.508	.621	.493	.388	.488
Character of the soil	Virgin soil.	Cultivated soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

These soils do not appear to have been derived from the sandstone which underlies them, being richer than might be expected from such an origin, and containing no great quantity of sand. They have doubtless been formed by the disintegration of other superincumbent strata, richer in the fertilizing mineral elements, or been modified by the admixture of light drift material. The exhausting influence of culture is to be seen in each case, as shown by the generally smaller proportions of potash, phosphoric acid, organic and volatile matters, &c., and the large quantity of sand and insoluble silicates in the old field soil, as compared with the virgin soil of the next adjoining field.

These soils are not generally deficient in potash, except soil No. 1838, but their proportion of phosphoric acid is generally small, so that there is every reason to believe they would be much improved in productiveness by the use of phosphatic fertilizers, such as bone dust, superphosphate, or guano. As the tobacco culture is especially exhaustive of potash and lime, wood ashes, or some other fertilizer containing potash, might be advantageously used, together with the judicious application of lime. Both of these are best used with a clover crop, which should be plowed in after a growth of one or two years. By such a process the old exhausted fields might be greatly improved.

JACKSON COUNTY.

COALS.

No. 1846—"*Cannel Coal, from Tom Coyle's bank, seventeen miles southeast of Richmond. Represented to be twenty-one inches cannel and twenty-one inches bituminous coal. Bed about one hundred feet above the conglomerate. Sample from the weathered outcrop. By Wm. A. Gunn, Esq., Civil Engineer.*"

A rather dull-looking cannel coal. Splitting, with difficulty, into layers, with not enough fibrous coal to soil the fingers, and no apparent pyrites.

272

No. 1847—"*Cannel Coal, from T. J. Ballard's bank. Branch of Horse Lick, twenty-six miles from Richmond. A sub-conglomerate coal. Specimen from the outcrop. By Wm. A. Gunn, Esq.,*" *&c.*

Resembles the preceding. Has a bird-eye structure in parts.

COMPOSITION OF THESE JACKSON COUNTY COALS, AIR-DRIED.

	No. 1846.	No. 1847.
Specific gravity	1.338	1.321
Hygroscopic moisture	2.00	2.00
Volatile combustible matters	41.00	43.66
Coke	57.00	54.34
Total	100.00	100.00
Total volatile matters	43.00	45.66
Fixed carbon in the coke	43.10	45.58
Ash	13.90	8.76
Total	100.00	100.00
Character of the coke	Spongy.	Dense.
Color of the ash	Very light buff-grey.	Grey-lavender.
Per centage of sulphur	1.049	3.384

Although No. 1846 contains more than the average proportion of earthy matters, it is yet quite valuable for fuel, especially for domestic purposes. No. 1847 is not so liable to this objection, and is a very good cannel coal.

JESSAMINE COUNTY.

MINERAL WATER.

No. 1848—"*Salt Sulphur Water, from a bored well, ninety feet deep, at Nicholasville. Brought by Mr. R. A. Downing.*"

The water was obtained at eighty feet, and stands in the well at sixty feet from the surface. Lower Silurian formation.

Specific gravity of the water = 1.023.

The water when brought to the laboratory smelt slightly of sulphuretted hydrogen, and was quite cloudy from the presence of free sulphur, derived from the decomposition of that gas. It also contained free carbonic acid gas.

The per centage of *saline matters* contained in it is 2.828, dried at 212° F. They consist of lime and magnesia sulphates, and a considerable proportion of sodium chloride, with some lime, magnesia, and iron carbonates, marked traces of lithia, iodine, and bromine, and doubtless of salts of potash and soda.

A quantitative analysis was not made at this time, but the water resembles the salt sulphur waters generally obtained by boring into the Lower Silurian limestone formation, of which several analyses are given in previous volumes, and all of which are more or less like the celebrated waters of the Blue Lick Springs.

JOHNSON COUNTY.

COALS.

No. 1849—"*Cannel Coal, twenty-seven inches thick. Lick Branch, half a mile above the mouth of White House Creek. Ten miles above Peach Orchard. Collected by A. R. Crandall.*"

Contains some bright pyrites, and is somewhat incrusted with ferruginous material. Is generally a tough cannel coal.

No. 1850—"*Rice's Coal. Head of Jenny's Creek. Thirty inches thick. Average sample by A. R. Crandall.*"

A pure-looking, glossy-black coal, with but very little fibrous coal or pyrites. Somewhat hard and not breaking into so thin laminæ as the usual splint coals. Ferruginous stains on some of the seams.

No. 1851—"*Coal, from Wheeler's bank, near Paintsville. Bed four feet six inches thick, without parting. Average sample by A. R. Crandall.*"

A pure-looking, pitch-black coal. Rather firm. Has but little fibrous coal. Some few bright pyritous scales apparent.

COMPOSITION OF THESE JOHNSON COUNTY COALS, AIR-DRIED.

	No. 1849.	No. 1850.	No. 1851.
Specific gravity	1.291	1.294	1.281
Hygroscopic moisture	2.00	3.10	2.66
Volatile combustible matters	38.20	38.60	38.04
Coke	59.80	58.30	59.30
Total	100.00	100.00	100.00
Total volatile matters	40.20	41.70	40.70
Fixed carbon in the coke	51.00	53.50	56.30
Ash	8.80	4.80	3.00
Total	100.00	100.00	100.00
Character of the coke	Dense.	Light Spongy.	Spongy.
Color of the ash	Light lilac-grey.	Light brownish-grey.	Brownish-grey.
Percentage of sulphur	0.956	1.735	1.291

Remarkably good coals, containing less than the usual proportions of sulphur and earthy matters. Being also quite firm, they might very probably be employed, without coking, in the smelting of iron in the high furnace.

KNOX COUNTY.

No. 1852—FERRUGINOUS LIMESTONE. *Labeled "Rock from Poplar Creek; farm of W. H. Hutching. Specimen obtained from Col. John G. Eve by Prof. N. S. Shaler; together with a specimen of metal smelted from it."*

A compact, fine granular, grey rock; weathered yellowish-brown on the exterior. Fracture flat conchoidal. Some very small bright crystals of pyrites on the seams.

COMPOSITION, DRIED AT 212° F.

Iron carbonate	13.532	= 6.532 per cent. of iron.
Alumina	2.699	
Manganese carbonate	not det'd.	
Lime carbonate	42.260	
Magnesia carbonate	3.072	
Phosphoric acid	.089	
Sulphuric acid	not det'd.	
Silicious residue	31.860	
Undetermined and loss	6.488	
	100.000	

This ferruginous limestone is too poor for use in smelting, except in mixture with richer ores, to answer as flux. Possibly it might make a hydraulic cement if properly calcined.

The bright white metal which accompanied this limestone, said to have been smelted from it, and supposed to contain silver, is simply white pig metal, containing more than ninety-two per cent. of iron, nearly one per cent. of phosphorus, 0.785 per cent. of silicon, 0.104 per cent. of sulphur and carbon, &c. It is quite brittle and crystalline, somewhat in appearance like antimony. Its color is more grey than that of silver.

KNOX COUNTY SOILS.

No. 1852 (*a*)—"*Virgin Soil, from the farm of A. B. Britton, three miles north of Barbourville, at the foot of Paint Hill Knobs. Collected by C. W. Beckham. Rock substratum; sandstone.*"

Dried soil of a light-brownish-grey color; contains some rounded ferruginous concretions. The bolting-cloth removed from the silicious residue a considerable proportion of small irregular particles of partly decomposed silicates, and a few minute scales of mica.

No. 1852 (*b*)—"*Surface Soil, from a field twenty years in cultivation, from same farm and near the locality of the next preceding. Collected by C. W. Beckham.*"

Dried soil, containing some friable lumps, of a light-grey, clayey soil, mixed with a light mouse-colored powdered soil and some ferruginous sandstone and cherty fragments. The bolting-cloth separated from the silicious residue a consider-

able portion of particles of partly decomposed silicates (as above).

No. 1852 (*c*)—"*Virgin Soil, from the top of Paint Hill Knob, three and a half miles north of Barbourville. Forest growth almost exclusively oak, hickory, and chestnut. (Location of a Signal Station of the U. S. Coast Survey.) Substratum sandstone. Collected by C. W. Beckham.*"

Dried soil of a dark, brownish-grey color; contains small cherty and ferruginous sandy fragments. The bolting-cloth removed from the silicious residue a considerable portion of minute particles of undecomposed silicates, a few reddish rounded quartzose particles and minute scales of mica.

No. 1852 (*d*)—"*Virgin Soil, from woods, on the farm of Judge Tuggle, one and a third miles south of Barbourville, in the Cumberland River Valley. Principal forest growth: oaks, hickories, &c. Substratum sandstone. Collected by C. W. Beckham.*"

Dried soil of a light-umber-grey color. Quite a light soil—as light as wood ashes—contains no gravel. The bolting-cloth removed from the silicious residue a considerable proportion of small rounded quartzose grains.

No. 1852 (*e*)—"*Surface Soil, from an old field sixty years in cultivation; now in meadow. Same locality as the next preceding,*" *&c., &c.*

Dried soil of a lighter umber-grey than preceding; resembles it in other respects.

No. 1852 (*f*)—"*Subsoil of the next preceding,*" *&c., &c.*

Dried soil of a lighter grey-buff color; contains no gravel, &c. (as above).

COMPOSITION OF THESE KNOX COUNTY SOILS, DRIED AT 212° F.

	No. 1852 *a*	No. 1852 *b*	No. 1852 *c*	No. 1852 *d*	No. 1852 *e*.	No. 1852 *f*.
Organic and volatile matters	3.453	4.374	5.658	2.800	2.765	1.750
Alumina and iron and manganese oxides	5.456	8.781	7.825	2.835	1.904	3.644
Lime carbonate	.100	.120	.095	.045	.130	.045
Magnesia	.158	.158	.158	.016	.029	.025
Phosphoric acid	.179	.104	.185	.055	.061	.031
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.125	.261	.467	.112	.094	.130
Soda	.576	not est.	not est.	.021	not est.	not est.
Sand and insoluble silicates	89.115	85.165	84.765	93.790	94.530	93.215
Water expelled at 380° F.	.741	.621	.909	.525	.535	1.675
Loss	.097	.416	.....	.....	.....	.....
Total	100.000	100.000	100.062	100.199	100.048	100.515
Hygroscopic moisture	0.815	0 900	1.025	0.950	0.435	0.435
Potash in the insoluble silicates	1.648	1.648	2.320	0.399	.409	.718
Soda in the insoluble silicates	.130	.446	.546	.235	.150	.119
Character of the soil	Virgin soil.	Cultivated soil.	Virgin soil.	Virgin soil.	Old field soil.	Subsoil.

Soils *a*, *b*, and *c* contrast favorably with soils *d*, *e*, and *f*; containing less sand and insoluble silicates and more potash, phosphoric acid, organic and volatile matters, &c. A marked difference may also be observed in the proportion of alkalies contained in the insoluble silicates. The first three named soils, indeed, are peculiar in containing more silicates of the felspathic and micaceous character than common, indicating a different origin from the latter named soils, and containing a large proportion of the alkalies. The soils *d*, *e*, and *f* may be called quite poor, naturally; but they can be made productive by proper management and the use of fertilizers, if they are sufficiently drained.

LAUREL COUNTY.

SOILS.

No. 1853—"*Virgin Soil, from a farm near Jackson's Steam Mill, nine miles south of London. Forest growth principally oaks and hickories. Geological formation, carboniferous sandstone. Collected by C. W. Beckham.*"

Dried soil of a brownish umber-grey color; contains some irregular fragments of ferruginous sandstone. The bolting-cloth separated from its insoluble silicious residue quite a large proportion of small rounded white quartz grains.

No. 1854—"*Surface Soil, from an old field. Same locality as the preceding*," *&c.*

Dried soil of a lighter and more yellowish color than the preceding; contains less of fragments of ferruginous sandstone, but fully as much of fine rounded white quartz grains.

No. 1855—"*Subsoil of the preceding*," *&c.*

Of a still lighter and more yellowish color (brownish-grey); contains no gravel, but a large proportion of minute white quartz grains.

No. 1856—"*Virgin Soil, from woods. Farm of Jefferson Cannifax, half a mile south of London. Forest growth almost exclusively oaks, a few maples, hickories, &c. Collected by C. W. Beckham.*"

Dried soil of a brownish umber-grey color; containing clods of somewhat lighter color. Contains fragments of ferruginous sandstone or concretions in considerable quantity. Silicious residue contains some rounded white quartz grains.

No. 1857—"*Surface Soil, from an old field sixty-five years in cultivation; uninclosed. Said to be worn out. Adjoining the woods from whence the preceding sample was taken. Substratum, carboniferous sandstone. Collected by C. W. Beckham.*"

Soil lighter colored than the preceding; contains fragments of ferruginous concretions or sandstone. Silicious residue contained some rounded white quartz grains.

No. 1858—"*Subsoil of the next preceding*," *&c.*

Dried subsoil of a brownish-buff color; contains some ferruginous sandy concretions; less than in the two preceding. The insoluble silicious residue contained but a few quartzose grains.

COMPOSITION OF THESE LAUREL COUNTY SOILS, DRIED AT 212° F.

	No. 1853	No. 1854	No. 1855	No. 1856	No. 1857	No. 1858
Organic and volatile matters. . .	6.110	3.625	2.450	5.990	3.475	3.740
Alumina and iron and mang. ox's	5.298	4.882	5.719	7.339	7.361	9.385
Lime carbonate	.110	.130	.145	.070	.120	.110
Magnesia	.011	.025	.016	.124	.053	.075
Phosphoric acid	.077	.083	.071	.096	.099	.100
Potash	.229	.312	.110	.217	.074	.447
Soda	.149	.268	.228	. . . .	. . . .	. . . .
Sand and insoluble silicates . . .	87.330	90.230	90.780	84.415	87.740	85.365
Water, expelled at 380° F. . . .	1.100	.725	.400	1.075	.675	.725
Loss	. . . .	. . . .	.081	.674	.403	.053
Total	100.414	100.280	100.000	100.000	100.000	100.000
Hygroscopic moisture.	0.865	0.550	0.575	1.535	0.800	1.425
Potash in the insoluble silicates .	.843	.661	.892	.939	.862	.975
Soda in the insoluble silicates . .	.171	.211	.214	.400	.623	.575
Character of the soil	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

These soils are pretty uniform in character, and, but for a paucity of phosphoric acid, which may be seen in them all, would be classed as of good average quality.

LAWRENCE COUNTY.
BLACK BAND IRON ORES.

No. 1858—"*Black Band Ore, from near Louisa; sent by Col. John Rice. Bed said to be thirty-one inches thick, of which twelve to sixteen inches are black-band, the rest bituminous shale.*"

A dull greyish-black, fine granular ore; some little bright-yellow pyrites apparent.

No. 1858 (*a*)—"*Black Band Ore, from same locality as preceding. (Gavat farm, on the west fork of Big Sandy river. A four to six feet bed of coal just below it.) Brought by Mr. John R. Procter.*"

No. 1858 (*b*)—"*Average sample of the Black Band Iron Ore, on Louisa Fork of Big Sandy river, six miles south of Louisa. Collected by A. R. Crandall.*"

Thickness of the layer about two feet, of which only about eight to twelve inches are of Black Band Ore. Latterly it has been reported as sixteen inches, at the bottom of the black shale which constitutes most of the bed.

These several samples were examined as to their proportions of iron, phosphorus, sulphur, &c., with the following results:

	No. 1858.	No. 1858 *a*.	No. 1858 *b*.
Specific gravity	3.151	not det'd.	not det'd.
Iron	33.264	33.923	25.746
Phosphorus	not det'd.	not det'd.	.553
Sulphur	.483	not det'd.	.354
Lime	not det'd.	not det'd.	.924
Magnesia	not det'd.	not det'd.	.150
Bituminous matters	not det'd.	not det'd.	13.700
Silica	7.460	not det'd.	6.360
Alumina	not det'd.	not det'd.	17.920

The iron is mostly in the form of carbonate in the ore, as are also the lime and magnesia, and the phosphorus and sulphur in that of phosphoric and sulphuric acids. The proportions of these two latter ingredients are somewhat large, but yet not so great as to prevent this ore from being made profitably available for foundry iron, &c., if it is to be obtained in sufficient abundance and as rich in iron as the samples 1858 and 1858 (*a*).

LAWRENCE COUNTY COALS.

No. 1859—"*Peach Orchard Coal.* (*Coal No.* 3.) *Miller's Branch opening. Collected by A. R. Crandall.*"

A pitch-black coal, breaking in thin laminæ, with some fibrous coal and fine granular pyrites between. Some external ferruginous stain.

No. 1860—"*Peach Orchard Coal.* (*Coal No.* 3.) *Same locality. Sample somewhat weathered. Collected by A. R. Crandall.*"

No. 1861—"*Cannel Coal. Little Laurel Creek. Collected by A. R. Crandall.*"

Shows very little pyrites.

COMPOSITION OF THESE LAWRENCE COUNTY COALS, AIR-DRIED.

	No. 1859.	No. 1860.	No. 1861.
Specific gravity	1.317	not est.	1.245
Hygroscopic moisture	3.26	3.24	1.84
Volatile combustible matters	34.22	36.56	48.16
Coke	62.52	60.20	50.00
Total	100.00	100.00	100.00
Total volatile matters	37.48	39.80	50.00
Fixed carbon in the coke	55.36	54.96	44.74
Ash	7.16	5.24	5.26
Total	100.00	100.00	100.00
Character of the coke	Dense.	Dense.	Dense.
Color of the ash	Light brownish-grey.	Light lilac-grey.	Buff.
Per centage of sulphur	0.901	1.189	1.076

The Peach Orchard coal has a high reputation where it is brought into market, and many samples show a much smaller proportion of ash than is given above. An analysis reported by the late Dr. Owen (volume I, old series, Kentucky Geological Reports, page 69) gives only the small ash per centage of 2.85. The proportion of sulphur is also quite small. This coal is a semi-cannel or splint coal, and might very probably be employed with advantage in the smelting of iron, without coking. It is an admirable fuel for domestic purposes.

LAWRENCE COUNTY LIMONITE IRON ORES.

No. 1862—"*Limestone Ore; portions of three samples, from different localities, mixed. On upper Blaine Creek. Collected by A R. Crandall.*"

282

No. 1863—"*Red Kidney Ore, from near the mouth of Cherokee Creek, about fifty feet above the limestone ore. Collected by A. R. Crandall.*"

COMPOSITION OF THESE LIMONITE ORES, DRIED AT 212° F.

	No. 1862.	No. 1863.
Iron peroxide	67.515	55.693
Alumina	1.280	1.151
Manganese oxide	not est.	not est.
Lime carbonate	a trace.	a trace.
Magnesia	a trace.	a trace.
Phosphoric acid	.135	.284
Sulphuric acid	.423	.302
Combined water	10.150	10.510
Silicious residue	20.480	31.280
Loss	.017	.780
Total	100.000	100.000
Per centage of iron	47.250	39.105
Per centage of phosphorus	.059	.124
Per centage of sulphur	.175	.111
Per centage of silica	16.960	25.660

These are quite good iron ores, rich enough in iron, and containing less than the usual proportion of phosphorus.

No. 1864—"BITUMINOUS SILICIOUS PETRIFACTION. *Irish Creek. Probably associated with Coal No. 2. Collected by A. R. Crandall.*"

Presenting the appearance of fibrous coal which has been infiltrated with silica.

COMPOSITION, AIR-DRIED.

Silica and silicates	80.66
Carbonaceous matter	13.40
Alumina and iron oxide, &c.	1.80
Lime carbonate	.26
Water and loss	3.88
Total	100.00

LEE COUNTY.

COALS.

No. 1865—"*Coal, from Daniel Scott's bank, three quarters of a mile above Proctor. Bed thirty-six inches thick. Sample by A. R. Crandall.*"

A pitch-black splint coal, having but little fibrous coal. Some fine granular pyrites between the thin laminæ.

No. 1866—"*Coal, from the same locality as the last, from another entry. Bed forty-one inches thick. Sample by A. R. Crandall.*"

Resembles the preceding.

No. 1867—"*Pryse's Coal. Lower Stufflebean Creek. Three quarters of a mile west of Beattyville. Average sample from two places, two hundred and two hundred and eighty-six yards from the mouth of the entry. By A. R. Crandall. Thickness of bed thirty-six to forty inches.*"

A pure-looking, pitch-black, glossy splint coal, with very little fibrous coal and fine granular pyrites between the laminæ.

No. 1868—"*Coal, from Phillips' bank, on Mirey Branch. Probable average thickness of the bed forty inches. Average sample from the stock pile, by A. R. Crandall.*"

Resembles the preceding; contains some small scales of bright pyrites.

No. 1869—"*Coal, from R. B. Jameson's bank, two miles below Beattyville, on Mike's Branch. Average sample by A. R. Crandall.*"

A splint coal. Has some fibrous coal and granular pyrites.

COMPOSITION OF THESE LEE COUNTY COALS, AIR-DRIED.

	No. 1865.	No. 1866.	No. 1867.	No. 1868.	No. 1869.
Specific gravity	1.331	1.334	1.307	1.307	1.330
Hygroscopic moisture	2.30	2.10	4.00	3.10	3.40
Volatile combustible matters . .	38.10	38.10	35.50	36.64	32.70
Coke	59.60	59.80	60.50	60.26	63.90
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.40	40.20	39.50	39.74	36.10
Fixed carbon in the coke . . .	51.64	51.54	55.50	56.96	57.60
Ash	7.96	8.26	5.00	3.30	6.30
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Light spongy.	Dense spongy.	Spongy.
Color of the ash	Lilac-grey.	Lilac-grey.	Light lilac-grey.	Light buff-grey.	Light lilac-grey.
Per centage of sulphur	2.356	3.991	1.041	1.030	1.368

These coals resemble, in their general properties, those of Lawrence county, reported on above; and although some of these contain a little more sulphur than those, the remarks appended to the latter are equally applicable to these.

LEWIS COUNTY.

SOILS.

No. 1870—"*Soil, from the Ohio bottom, border of creek; ten feet from its surface, about three and a half miles above Quincy. Collected by N. S. Shaler.*"

Dried soil mostly in friable lumps, of a light brownish-grey color; contains no gravel. Silicious residue contains quartzose sand, which will not pass through fine bolting-cloth.

No. 1871—"*Subsoil of the preceding; taken one to three feet below the surface,*" *&c., &c.*

Dried subsoil in friable lumps, somewhat lighter colored than the surface soil; of a light yellowish-grey color.

No. 1872—"*Old Field Soil, cultivated for over fifty years; never overflowed. Back of the Ohio bottom, on Scaffold (or "Scuffle") Creek, three and a half miles above Quincy, and above locality of the two preceding. Produces forty bushels of corn to the acre on an average. Collected by N. S. Shaler.*"

Dried soil of a light-grey color, slightly less yellowish than the next preceding, and slightly darker.

COMPOSITION OF THESE LEWIS COUNTY SOILS, DRIED AT 212° F.

	No. 1870.	No. 1871.	No. 1872.
Organic and volatile matters	3.325	2.665	4.425
Alumina and iron and manganese oxides	10.965	8.995	9.545
Lime carbonate	.125	a trace.	.180
Magnesia	.266	.092	.208
Phosphoric acid	.125	.125	.205
Sulphuric acid	a trace.	.015	.050
Potash	.501	.387	.462
Soda	.116	.128	.134
Soluble silica	.095	.095	.085
Sand and insoluble silicates	83.465	86.365	83.100
Water expelled at 380° F.	1.025	.685	1.725
Loss	. . . . .	.448	. . . . .
Total	100.008	100.000	100.119
Hygroscopic moisture	3.000	2.225	2.335
Potash in the insoluble silicates	1.843	1.233	1.138
Soda in the insoluble silicates	1.036	.868	.954
Character of the soil	Surface soil.	Subsoil.	Old field soil.

These soils, evidently composed of fine detritus deposited by the water of the river, contain more than the average quantity of potash in a state of combination soluble in acids, and hence immediately available for plant growth. The proportions of organic and volatile matters, of phosphoric acid and lime, as well as of the alkalies in the insoluble silicates, are not more than the average. No. 1871 subsoil is especially deficient in lime. Yet they may well be characterized as fertile soils, more especially No. 1872.

LINCOLN COUNTY.

No. 1873—"CLAY, *from the head waters of Green river, on the land of Mr. Thos. W. Varnon. Bed two to four feet from the surface, and said to be forty-two to forty-five feet thick; resting on black shale, which is fifty feet thick. Salt water is found by boring at the depth of eighty-four feet, and some little petroleum in the sandstone. Sent by Senator Varnon.*"

Clay imperfectly laminated, of a dark olive-grey color. Fuses before the blow-pipe. Burns of a grey-buff color.

COMPOSITION, DRIED AT 212° F.

Silica	61.580
Alumina	23.946
Iron protoxide	5.814
Lime	.201
Magnesia	.850
Potash	1.542
Soda	.362
Water and loss	5.705
Phosphoric acid	not det'd.
Total	100.000

The considerable proportions of the iron oxide, lime, potash, and soda prevent this clay from being refractory in the fire. But while it is therefore unfit for the manufacture of fire-bricks, it will yet answer well for ordinary pottery, terra cotta work, or tiles.

CRAB ORCHARD SALTS (SO-CALLED).

The saline matters obtained by the evaporation of the saline waters of Crab Orchard and vicinity, Lincoln county.

No. 1874—"*Crab Orchard Springs Salts; put up by the Crab Orchard Salts Company. Said to be obtained from the waters of various springs mixed. Evaporated at the Springs, and warranted genuine, as sold in sealed bottles by J. B. Wilder & Co., Louisville.*"

A granular salt, colored light-buff with iron peroxide. Dried for about a month, in the water-bath it lost 33.715 per cent. of

its weight by the evaporation of water; mainly water of crystallization.

No. 1875—"*Crab Orchard Salts; furnished by Messrs. Arthur Peter & Co., Louisville, from their stock; obtained by Dr. Luney Egbert, druggist, of Crab Orchard. Said also to be derived from various springs.*"

This also is in granular lumps, and presents various shades of buff color, from the presence of iron peroxide.

COMPOSITION OF THESE SAMPLES OF CRAB ORCHARD SALTS, DRIED AT 212° F.

	No. 1874.	No. 1875.
Magnesia sulphate	54.842	60.627
Soda sulphate	13.566	8.260
Potash sulphate	2.707	2.814
Lime sulphate	2.149	1.795
Lithia sulphate	.038	.028
Sodium chloride	2.954	1.874
Lime carbonate	.032	.018
Magnesia carbonate	.089	.036
Iron peroxide	.078	.028
Silica	.124	.118
Water of crystallization and loss	23.421	24.402
Total	100.000	100.000

These salts have quite an extensive medicinal use in some localities. The proportions of lithium salt shown in the above analyses is not so great as is generally claimed for these salts.

MADISON COUNTY.

CLAYS.

No. 1876 (*a*)—"*Potter's Clay (quality No. 1). Upper Silurian. Waco, nine miles east of Richmond. Collected by A. R. Crandall.*"

A light-grey soft clay, with some ochreous stains and infiltration.

No. 1876 (*b*)—"*Potter's Clay (quality No. 2). Same locality,*" *&c., &c.*

Of a bluish-grey color.

COMPOSITION OF THESE CLAYS, DRIED AT 212° F.

	No. 1876 *a*.	No. 1876 *b*.
Silica	59.976	56.960
Alumina, iron and manganese oxides, and phosphoric acid	27.640	28.740
Lime carbonate	.280	.200
Magnesia	.606	.752
Potash	3.931	2.502
Soda	.547	.315
Combined water and loss	7.020	10.531
Total	100.000	100.000

Neither of these would answer for fire-clay, because of their large proportions of alkalies, lime, magnesia, iron oxide, &c. The iron was not separately determined, and hence the reason why the one is better than the other for the use of the potter was not clearly ascertained. Possibly the smaller proportion of silica and larger amount of alumina, iron oxide, &c., have something to do with it. These are good clays for ordinary stone-ware, &c.

MADISON COUNTY COALS.

No. 1877—"*Coal, from Cox's coal bank. Top of Big Hill. Bed forty inches thick. A sub-conglomerate coal. Average sample by A. R. Crandall.*"

A deep-black splint coal, splitting into very thin laminæ, with much fibrous coal and some little pyrites, some of which is in a small shot form.

No. 1878—"*Coal, from M. Moran's mine. Top of Big Hill, on the road. Bed said to be thirty-six to forty-four inches thick. A sub-conglomerate coal. Sample (more sulphurous than usual) brought by Mr. Wm. A. Gunn, Civil Engineer, &c.*"

A pretty pure-looking splint coal, with very little fibrous coal, but considerable fine granular pyrites between the laminæ.

COMPOSITION OF THESE MADISON COUNTY COALS.

	No. 1877.	No. 1878.
Specific gravity	1.281	1.282
Hygroscopic moisture	2.66	1.90
Volatile combustible matters	33.68	45.76
Coke	63.66	52.34
Total	100.00	100.00
Total volatile matters	36.34	47.66
Fixed carbon in the coke	56.16	44.86
Ash	7.50	7.48
Total	100.00	100.00
Character of the coke	Dense spongy.	Dense.
Color of the ash	Nearly white.	Nearly white.
Per centage of sulphur	0.824	2.888

These two samples, from the same bed evidently, present remarkable differences; No. 1878 giving off much more volatile combustible matters, and leaving less carbon in the coke than the other, approaching more nearly to the character of a cannel coal than that. The relative proportions of sulphur are also very different; all illustrating the great variations in composition which may appear between a selected hand specimen and an average sample of the whole bed. The coke obtained from No. 1877 is somewhat dense and fine cellular.

MAGOFFIN COUNTY.

COALS.

No. 1878 (*a*)—"*Salyersville Coal. Lower part; fourteen inches thick. Half cannel. Collected by A. R. Crandall.*"

A sample partly cannel and partly bright bituminous or splint coal. No apparent fibrous coal or pyrites.

No. 1879—"*Salyersville Coal. Upper part; eighteen inches thick. Collected by A. R. Crandall.*"

A pure-looking, pitch-black coal, with very little fibrous coal and no apparent pyrites.

No. 1880—"*Coal, from Amos Davis' bank, on Licking river. Bed forty-four inches thick, with a five-inch parting. Sample by A. R. Crandall.*"

A firm, pitch-black splint coal, with some fibrous coal and fine granular pyrites between its thin laminæ.

No. 1881—"*Coal, from Stacye coal bank, near the mouth of Johnson's Creek. Bed four feet thick, without parting. Average sample from near the outcrop. By A. R. Crandall.*"

A somewhat mixed sample. Mostly bright, pitch-black coal, with some little dull, and seemingly cannel coal.

No. 1882—"*Colvin's Cannel Coal. Bed three feet thick. Average sample from the main outcrop. By A. R. Crandall.*"

Rather a dull-looking cannel coal. Portions showing a somewhat fibrous structure; other portions splitting into thin laminæ. Has very little fibrous coal and no apparent pyrites. Surfaces soiled somewhat with dirt.

COMPOSITION OF THESE MAGOFFIN COUNTY COALS, AIR-DRIED.

	No. 1878*a*.	No. 1879.	No. 1880.	No. 1881.	No. 1882.
Specific gravity	1.275	1.292	1.309	1.270	1.236
Hygroscopic moisture	1.80	2.70	4.34	3.70	2.30
Volatile combustible matters	45.60	38.04	37.36	36.64	51.90
Coke	52.60	59.26	58.30	59.66	45.80
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	47.40	40.74	41.70	40.34	54.20
Fixed carbon in the coke	43.40	51.62	53.14	54.68	37.56
Ash	9.20	7.64	5.16	4.98	8.24
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense spongy.	Light spongy.	Spongy.	Light spongy.	Very dense.
Color of the ash	Buff-grey.	Very light bro'h-grey.	Light purplish-grey.	Light buff-grey.	Brownish-grey.
Per centage of sulphur	0.688	1.470	1.357	0.944	1.415

All of these coals are good, and most of them very good, containing but a moderate or small proportion of ash, and less than the usual quantity of sulphur. The cannel coals, although leaving more ash than the others, would doubtless produce fully as much heat, in equal weights of the coals, because of their larger proportions of hydrocarbons: it being a well-established fact that *hydrogen* will give out three times as much heat as *carbon*, when they are burned in equal weights.

MARTIN COUNTY.

COALS.

No. 1883—"*Coal No. 1, from Warfield. Mouth of Collins' Creek. Entry near the salt-works. Average sample from upper four and a half feet bed. By A. R. Crandall.*"

A jet-black, pure-looking coal, breaking into thin laminæ, with some fibrous coal and fine granular pyrites between.

No. 1884—"*Coal. Warfield. Opening in the face of the hill on Tug Fork, three hundred feet above low water. Sample by A. R. Crandall.*"

Aspect of the coal a little more dull than that of the preceding.

No. 1885—"*Warfield Splint Coal. Three hundred and one feet above the main Warfield coal. Bed three feet thick, with two thin clay partings. Sample by A. R. Crandall.*"

Has fibrous coal between the laminæ, but little appearance of pyrites. Some little ferruginous stain on the seams.

No. 1886—"*Eight Feet Coal. Head of Laurel Fork of Nat's Creek. Sample from an old opening. By A. R. Crandall.*"

Rather a dull-looking coal. Has but little fibrous coal and no apparent pyrites between the laminæ. Some little ferruginous stain.

No. 1887—"*Coal No. 1. Warfield. Sample from two rooms. By A. R. Crandall.*"

Generally a glossy, pitch-black splint coal. Has very little fibrous coal, generally, between the laminæ. Some thin scales of brassy pyrites in some of the seams, and occasional layers of fibrous coal with granular pyrites

COMPOSITION OF THESE MARTIN COUNTY COALS, AIR-DRIED.

	No. 1883.	No. 1884.	No. 1885.	No. 1886.	No. 1887.
Specific gravity	1.351	1.358	1.358	1.367	1.302
Hygroscopic moisture	2.16	2.50	2.24	3.50	2.00
Volatile combustible matters	33.60	33.70	33.06	31.94	35.12
Coke	64.24	63.80	64.70	64.56	62.88
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.76	36.20	35.30	35.44	37.12
Fixed carbon in the coke	55.06	52.62	52.70	52.06	54.82
Ash	9.18	11.18	12.00	12.50	8.06
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Light spongy.	Dense.	Dense.	Dense.
Color of the ash	Brownish-grey.	Light lilac-grey.	Very light lilac-grey.	Very light lilac-grey.	Lilac-grey.
Per centage of sulphur	2.563	0.754	0.604	0.873	0.983

These Martin county coals generally contain rather more than the average amount of earthy matters, but less than the usual quantity of sulphur. Their rather large proportion of ash, however, does not materially detract from their value for use in manufacturing processes, or for fuel.

M'LEAN COUNTY.

No. 1888—"BITUMINOUS SHALE (*so-called cannel coal*), *from near Wrightsburg. Collected by C. J. Norwood.*"

A somewhat tough, dull-looking bituminous shale. Some ferruginous stain on the exposed surfaces.

No. 1889—"COAL, *from near Wrightsburg. Average sample by C. J. Norwood.*"

A jet-black, splint coal, with very little friable fibrous coal and granular pyrites between some of the thin laminæ.

COMPOSITION, AIR-DRIED.

	No. 1888.	No. 1889.
Specific gravity	not det'd.	1.241
Hygroscopic moisture	1.60	3.30
Volatile combustible matters	36.40	36.00
Coke	62.00	60.70
Total	100 00	100.00
Total volatile matters	38.00	39.30
Carbon in the coke	31.36	57.88
Ash	30.64	2.82
Total	100.00	100.00
Character of the coke	Friable.	Light spongy.
Color of the ash	Brownish lilac-grey.	Buff-grey.
Per centage of sulphur	not est.	1.024

The coal No. 1889 is remarkably pure and good. The bituminous shale or impure cannel coal might, in many cases, be profitably used as fuel, notwithstanding its large ash per centage.

MORGAN COUNTY.

COALS.

No. 1890—"*Pierat's Cannel Coal. Collected by A. R. Crandall.*"

A tough, somewhat dull-looking coal, breaking with difficulty into thin laminæ. Has a satiny lustre on its cross fracture. Contains no apparent pyrites or fibrous coal. The sample is mixed with a little attached brittle, glossy, splint coal.

No. 1891—"*Cannel Coal, from Maynhier's bank. Elk Fork of Licking river. Layer of cannel coal two feet two inches thick. Collected by A. R. Crandall.*"

A dull-black, clean-looking coal. Fracture somewhat fibrous across the laminæ. No fibrous coal or apparent pyrites.

No. 1892—"*Six-foot Coal. Near West Liberty. Collected by A. R. Crandall.*"

A soft splint coal, breaking into thin laminæ, with fibrous coal between, but no apparent pyrites.

COMPOSITION OF THESE MORGAN COUNTY COALS, AIR-DRIED.

	No. 1890.	No. 1891.	No. 1892.
Specific gravity	1.230	1.331	1.353
Hygroscopic moisture	2.06	2.30	4.26
Volatile combustible matters	49.64	41.60	35.24
Coke	48.30	56.10	60.50
Total	100.00	100.00	100.00
Total volatile matters	51.70	43.90	39.50
Fixed carbon in the coke	43.20	44.70	50.10
Ash	5.10	11.40	10.40
Total	100.00	100.00	100.00
Character of the coke	Spongy.	Very dense spongy.	Dense spongy.
Color of the ash	Light buff-grey.	Grey-buff.	Nearly white.
Per centage of sulphur	0.955	1.271	1.011

Cannel coal No. 1890 is remarkably pure and good; the others contain more than the average quantity of earthy matters, yet are profitable coals.

MEADE COUNTY.

No. 1893—"SALT WATER, *fresh from the well. Glen Font Salt-works. Collected by C. J. Norwood.*"

The water deposits a reddish sediment in the bottle, and gives an alkaline reaction after a time.

SPECIFIC GRAVITY OF THE WATER = 1.065.

COMPOSITION OF THE WATER IN 1000. PARTS.

Iron and manganese oxides, alumina and phosphoric acid,	0.055	Contained in the sediment deposited on boiling.
Lime carbonate	.654	
Magnesia carbonate	.018	
Silica	.005	
Sodium chloride	74.750	
Potassium chloride	.250	
Calcium chloride	9.050	
Magnesium chloride	2.080	
Barium chloride	.036	
Strontium chloride	.026	
Lithium chloride	.284	
Bromides and iodides	not est.	
Soluble silica	not est.	
	87. 208	

This brine, like that of the Goose Creek Salt-works, in Clay county (which see), contains notable quantities of barium and strontium chlorides; and as the former salt is considered injurious to the animal economy, it is well to get rid of it in the manufacture of the salt. This is easily to be done, as described under the head of the Goose Creek Salt-works.

One thousand parts of the water evaporated to dryness left a little more than one hundred parts of saline matters, dried at 212° F. The difference between that amount and the sum of the solid ingredients given in the analysis is doubtless owing to moisture, the undetermined ingredients, and unavoidable loss.

No. 1894—"THE BITTERN WATER, *from the Glen Font Salt-works.*"

The water has a slightly brownish color.

Specific gravity = 1.270.

This water, analyzed by my son, Alfred M. Peter, gave the following results:

COMPOSITION IN 100. PARTS.

Sodium chloride	3.206
Potassium chloride	.553
Calcium chloride	12.043
Magnesium chloride	13.314
Lithium chloride	.658
Barium chloride	.096
Strontium chloride	.147
Copper chloride	.008
Iodine	.002
Bromine	.382
Total	30.409

The trace of copper is doubtless due to the copper pipes, &c., in contact with the water. The proportion of lithium chloride is considerable. Whether there is enough bromine in it for profitable extraction depends on commercial and other circumstances.

Remarks on other probable useful applications of the bittern waters of salt-works will be found under the head of Goose Creek Salt-works, Clay county; also under the head of Grayson county marls.

With these samples there came a specimen of the "*salt water from the first settler*," which also had a brownish tint, and deposited a brownish sediment in the bottle.

Its *specific gravity* was 1.205, and it contained nearly twenty-six per cent. of dry saline matters.

Also "*water from the Grainer*," which had crystals of salt at the bottom. *Specific gravity* = 1.210.

It gave a little more than twenty-four per cent. of dried saline matters on evaporation, and was found to contain iodine equal to 0.009 per cent. of potassium iodide.

No. 1895—"SALT, *manufactured from the Glen Font brine. Collected by C. J. Norwood.*"

A moderately coarse-grained salt. Slightly damp with bittern water. Of a very light pinkish tint in the mass, from the presence of a little of the red sediment.

COMPOSITION, DRIED AT 212° F.

Sodium chloride (common salt) with traces of potassium and lithium chlorides	97.317
Calcium chloride	1.235
Magnesium chloride	1.415
Barium and strontium chlorides	traces only.
Insoluble residue (remains of red sediment)	.033
Total	100.000

This may be considered quite a pure salt as compared with the usual products of our salt-wells. The *traces* of barium salt are too small to be injurious; nor is the residue of red sediment injurious. The deliquescent salts, calcium, and magnesium chlorides, keep the salt always moist; they are said also to injure its antiseptic properties somewhat. These are easily removed by the addition of a little carbonate of soda—soda ash will do—which will precipitate lime and magnesia carbonates, and leave an equivalent of sodium chloride in solution. Thus purified, in the last operation before graining, the resulting salt would be perfectly dry and white and pure.

In addition to the above-described samples, the following were also received and examined from these salt-works, viz:

(*a*)—"*The hard red crust formed around the steam-pipe, where the heat is not great.*" (*A rather indefinite description.*)

This crust, of a handsome orange-red color in the interior and brown on the exterior, having a radiated fibrous structure, dissolved in chlorohydric acid with effervescence; and was found to consist mainly of lime, iron, and magnesia carbonates, &c.

(*b*)—"*The sediment formed inside the copper pipes conveying steam into the salt water.*"

A greenish-white, fibrous crust (colored thus slight by the action of the water on the copper), mainly made up of hexagonal prisms of lime carbonate. *An artificially formed* aragonite.

Testing showed no evidence of strontium in it, and only a trace of magnesium. The crystals, under the microscope,

appear beautifully transparent and colorless. The crust has the external form of the interior of the pipe, and is somewhat impregnated with the soluble salts of the water.

(*c*)—"*The sediment from the bottom of the settler.*"

A yellowish-brown mud, containing saline matters. When these were washed out the insoluble residue was found to consist mainly of lime carbonate and a little magnesia carbonate, colored with iron oxide.

These samples were all collected by C. J. Norwood.

MENIFEE COUNTY.

COALS.

No. 1896 (*a*)—"*Coal, from Price and Fitch's bank. Top of the mountain. Bed thirty-four inches thick. Sample from the coal yard of Richardson and Bosworth, Lexington.*"

A bright splint coal, breaking with difficulty across the laminæ; easily in their direction. Some reedy fibrous coal and bright thin pyritous plates between them.

No. 1896 (*b*)—"*Coal, from Adams' bank, near Frenchburg. Old Slate Branch. Average Sample collected by A. R. Crandall.*" *In the Sub-carboniferous limestone.*

A very pure-looking coal; glossy, pitch-black. Has very little fibrous coal or pyrites.

No. 1896 (*c*)—"*Coal. Old State Road Branch. Sample from the stock pile. By A. R. Crandall.*"

A very pure-looking, glossy, deep pitch-black coal. Very little fibrous coal or pyrites apparent.

No. 1896 (*d*)—"*Coal, from Steele's bank. Mouth of Brushy Fork of Beaver Creek. Collected by A. R. Crandall.*"

A pitch-black splint coal; not so glossy or black as 1896(*b*). Has some fine pyrites and fibrous coal between the laminæ.

COMPOSITION OF THESE MENIFEE COUNTY COALS, AIR-DRIED.

	No. 1896 *a*.	No. 1896 *b*.	No. 1896 *c*.	No. 1896 *d*.
Specific gravity	1.300	1.300	1.318	1.301
Hygroscopic moisture	5.00	5.00	2.70	3.80
Volatile combustible matters	39.06	32.40	38.22	38.60
Coke	55.94	62.60	59.08	57.60
Total	100.00	100.00	100.00	100.00
Total volatile matters	44.06	37.40	40.92	42.40
Fixed carbon in the coke	53.18	58.40	54.82	52.00
Ash	2.76	4.20	4.26	5.60
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Dense.	Spongy.	Light spongy.
Color of the ash	Brownish-lilac-grey.	Light yellowish-grey.	Lilac-grey.	Brownish-lilac-grey.
Per centage of sulphur	1.199	0.614	1.615	2.095

These are all remarkably good coals, containing less than the average of earthy matters, as well as of sulphur.

No. 1897—"LIMONITE IRON ORE. *Branch of Beaver Creek. Menifee county. Average sample by P. N. Moore.*"

COMPOSITION, DRIED AT 212° F.

Iron peroxide	54.750	= 38.750 per cent. of iron.
Alumina	14.517	
Manganese oxide	not est.	
Lime carbonate	a trace.	
Magnesia	.047	
Phosphoric acid	.697	= .304 phosphorus.
Sulphuric acid	a trace.	
Combined water	8.600	
Silicious residue	20.830	Containing 19.300 silica.
Loss	.559	
	100.000	

This is quite a good iron ore, with an average proportion of phosphoric acid, which will not injure it for all ordinary iron production. Its considerable proportion of alumina may help

to carry off much of this injurious ingredient in the furnace slag or cinder.

MUHLENBURG COUNTY.

COALS.

No. 1898—"*Coal B, from the Louisville and Stroud City mines. Owensboro Junction. 'Gas coal;' sixteen inches thick; at the top of the bed. Collected by C. J. Norwood.*"

A bright jet-black coal, with very little fibrous coal or pyrites apparent.

No. 1899—"*Coal B, from the same mine. Bed three to four feet thick. Owensboro Junction. Sample by C. J. Norwood.*"

A pitch-black, glossy coal. Has some fibrous coal and fine granular pyrites between some of the laminæ, and thin, bright pyritous and gypseous scales in some of the seams.

No. 1900—"*Coal B, from the Memphis Coal Company's mine, four miles south of Owensboro Junction, E., O. & N. R. R. From stock pile; probably from the top of the bed. Has been weathered for eighteen months, and is not a fair sample. Collected by C. J. Norwood.*"

A pitch-black coal, with but little fibrous coal or pyrites apparent.

No. 1901—"*Coal B. Bed four feet four inches to four feet eight inches thick. Saint Louis mines. Owensboro Junction. Sample by C. J. Norwood.*"

A pitch-black coal. Has some fibrous coal, and a few shining pyritous scales.

No. 1902—"*Coal B. Same mine as the next preceding. The 'gas coal;' sixteen inches thick. Collected by C. J. Norwood.*"

A pure-looking pitch-black coal. Has very little fibrous coal and no apparent pyrites.

No. 1903—"*Coal B. Rothrock's coal mine, a mile and a half north of Owensboro Junction. Upper bench; three feet nine inches thick. Average sample by C. J. Norwood.*"

Generally a pitch-black, glossy coal, with but little fibrous coal, &c., but the sample contained portions of an inch thick pyritous layer, weighing about nine per cent. of the whole, which was separated from the coal analyzed and examined separately (see 1903 *a*).

COMPOSITION OF THESE MUHLENBURG COUNTY COALS, AIR-DRIED.

	No. 1898	No. 1899	No. 1900	No. 1901	No. 1902	No. 1903
Specific gravity	1.280	1.309	1.313	1.235	1.307	1.332
Hygroscopic moisture	4.60	3.36	5.40	5.40	4.60	3.80
Volatile combustible matters	42.60	37.90	35.90	34.20	37.60	36.20
Coke	52.80	58.74	58.70	60.40	57.80	60.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	47.20	41.26	41.30	39.60	42.20	40.00
Fixed carbon in the coke	50.06	52.74	53.60	54.20	52.64	51.80
Ash	2.74	6.00	5.10	6.20	5.16	8.20
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.
Color of the ash	Light grey.	Light lilac-grey.	Light lilac-grey.	Bright lilac-grey.	Dark brownish-grey.	Lilac-grey.
Per centage of sulphur	1.601	2.686	2.219	3.136	2.372	3.194

No. 1903 (*a*)—The *pyritous shale*, separated from the general sample as above stated, left on incineration 65.90 per cent. of its weight of red-brown ash. It contained 27.64 per cent. of its weight of sulphur. If it had been left in the sample it would have increased the *ash* per centage of the whole to 13.394 per cent., and the *sulphur* per centage of the whole to 5.410 per cent. It was probably only accidentally present in the sample. This pyritous layer would certainly be rejected in preparing the coal for the market.

MUHLENBURG COUNTY SOILS.

No. 1903 (*a*)—"*Virgin Soil, from the farm of A. Stroud, twenty-seven miles from Owensboro. Collected by C. W. Beckham.*"

A clay soil, generally in lumps, breaking of a light bluish-grey color, with ferruginous infiltrations. Contains a small proportion of fine iron gravel. The bolting-cloth removed from the silicious residue a small quantity of small rounded grains of reddish and hyaline quartz.

No. 1903 (*b*)—"*Subsoil of the preceding*," *&c.*

Dried soil somewhat lighter colored than the preceding; contains rather more of rounded ferruginous concretions. The silicious residue contained some fine rounded quartzose grains.

No. 1903 (*c*)—"*Surface Soil, from a field about thirty years in cultivation; in grass all the time except for the last four years, when it was in corn and small grain. Underlying rock; sandy shale. Collected by C. W. Beckham.*"

Dried soil of a light, buff-grey color; contains some few ferruginous sandy concretions. The bolting-cloth separated from the silicious residue a considerable proportion of small rounded, clear and reddish quartz and silicate grains.

COMPOSITION OF THESE MUHLENBURG COUNTY SOILS, DRIED AT 212° F.

	No. 1903 *a*.	No. 1903 *b*.	No. 1903 *c*.
Organic and volatile matters	3.325	1.052	1.242
Alumina and iron and manganese oxides	4.137	3.548	3.749
Lime carbonate	.345	.006	.145
Magnesia	.176	.167	.122
Phosphoric acid	.198	.102	.121
Sulphuric acid	a trace.	a trace.	a trace.
Potash	.145	.167	.255
Soda	not est.	not est.	.477
Sand and insoluble silicates	90.215	94.340	93.140
Water, expelled at 380° F.	1.222	1.050	1.242
Total	99.763	100.432	100.493
Hygroscopic moisture	1.800	0.775	0.965
Potash in the insoluble silicates	1.339	1.091	1.113
Soda in the insoluble silicates	.716	.564	.474
Character of the soil	Virgin soil.	Old field soil.	Subsoil.

Soils of good average quality.

OHIO COUNTY.

COALS.

No. 1904—"*Coal D, from McHenry coal mine. McHenry Station. This sample does not include the 'sulphur band.' Collected by C. J. Norwood.*"

Quite a handsome, pitch-black, glossy coal. Has some fibrous coal between some of the laminæ, with granular pyrites, and some thin pyritous scales in the seams.

No. 1905—"*Coal D. Same locality as the preceding. This sample includes the 'sulphur band.' Collected by C. J. Norwood.*"

No. 1906—"*Coal D, from Render mine. Hamilton Station. Sample from the nut coal pile. Collected by C. J. Norwood.*"

A pure-looking, glossy-black coal; somewhat soft. Has very little fibrous coal, and no apparent pyrites. Some thin incrustation of gypsum in the seams.

No. 1907—"*Coal D, from same locality as next preceding. Sample from the slack pile. By C. J. Norwood.*"

No. 1908—"*Coal, from Charles Wesley Stephens'. On Rough Creek, above Hartford. Collected by C. J. Norwood.*"

A bright, pitch-black coal, breaking easily into irregular layers. Fracture often in natural joints, showing a coarse, irregular fibrous structure on surfaces. Contains but little fibrous coal. Some pieces show some thin scales of bright pyrites and gypsum.

No. 1909—"*Coal, from G. B. Hocker's coal bank. On Rough Creek, about four and a half miles above Hartford. Collected by C. J. Norwood:*"

Resembles the preceding; has fewer irregular seams, more fibrous coal, and fewer pyritous scales. Exterior with ferruginous stain.

No. 1910—"*Coal, from same locality as the next preceding,*" *&c., &c.*

Resembles the preceding, but is brighter and has less pyrites, &c. A very pure-looking coal. Some exterior ferruginous incrustation.

No. 1911—"*Coal, from Marion Sandifer's coal bank. Big Muddy Creek, one mile southwest from Elm Creek. Sampled from near the outcrop. May not be a fair sample of the bed. Collected by C. J. Norwood.*"

A dull-looking splint coal, with but little fibrous coal between the laminæ. Apparently weathered. Somewhat soiled with dirt, which will increase the apparent ash per centage. Sample also contains some bituminous shale, which will exert the same influence in the analysis. Not much apparent pyrites.

No. 1912—"*Coal, from L. M. Patterson's mine. Point Pleasant. Collected by C. J. Norwood.*"

A splint coal of irregular appearance. Portions are pitch-like; others are quite shaly. (Excluded from the sample a lump which seemed to be a portion of a pyritous parting.)

No. 1913—"*Coal D, from Williams' coal bank. On Ben's Lick. Point Pleasant road. Collected by C. J. Norwood.*"

Resembles the preceding; not much of it pitch-like on the cross fracture. Shows some scales of bright pyrites and some of gypsum. Not much fibrous coal present.

No. 1914—"*Bituminous Shale (so-called cannel coal). H. D. Bennett's coal bank; three miles north of Hartford. A lower coal? Collected by C. J. Norwood.*"

A dull, brownish-black, tough bituminous shale; in thin adherent laminæ, the cross-fracture of which is jet-like. Some exterior earthy stain.

No. 1915—"*Coal, from Berry and Walker's land. Head waters of North Fork of Muddy Creek, four miles east of Hartford, near Ben Hines' coal bank. At the old opening, first above the bank at Stanton Baltzel's. Probably not a fair average sample. Collected by C. J. Norwood.*" (*See No.* 1922.)

Much ferruginous and earthy incrustation on the exterior. Fracture bright, pitch-like. Very little appearance of fibrous coal, but some of pyrites. It seems to be a pure coal, with less lamination than ordinary splint coal.

No. 1916—"*Coal, from Bill Hines' coal bank, four miles east from Hartford. Sample from above the clay parting. By C. J. Norwood.*"

A bright, generally pitch-like coal, with some little fibrous coal, but with little appearace of pyrites between the laminæ. Not so much laminated as ordinary splint coal. Some ferruginous stains in the seams.

No. 1917—"*Coal, from the same bank. Sample from below the clay parting. By C. J. Norwood.*"

Resembles the next preceding; but more of it cleaves into thin laminæ, with fibrous coal between.

No. 1918—"*Coal E. On Rough Creek; mouth of Brush Creek; three miles below Hartford. Collected by C. J. Norwood.*"

A splint coal, mostly splitting into very thin laminæ, with reedy or dull-looking fibrous coal between. Very little appearance of pyrites. Some of the thin laminæ are pitch-like on the cross-fracture. Ferruginous and earthy stain on the exterior surfaces.

No. 1919—"*L. D. Taylor's Coal. Collected by C. J. Norwood.*"

A firm splint coal, splitting into pretty thin laminæ, with fibrous coal and some fine granular pyrites between. Some little bright pyritous scales in the seams.

No. 1920—"*Coal D, from Brown's coal bank, three miles south 40° west from Hartford. Taken from an entry where pyrites were abundant. By C. J. Norwood.*"

Some portions pitch-like; others dull. Generally separating into thin laminæ, with fibrous coal between. Bright pyritous scales and some scales of gypsum in the seams.

No. 1921—"*William Warden's Coal; near the roadside, about half a mile northwest from Centretown. From a heap, and consequently may not be an average sample. Coal covered. C. J. Norwood.*"

A rather firm coal. Some portions pitch-like. Some fibrous coal and granular pyrites between the laminæ.

No. 1922—"*Coal, from Berry and Walker's land. Hines' tract; in a ravine draining into North Fork of Muddy Creek. Sample from the lower two feet. An outcrop sample. By C. J. Norwood.*"

A splint coal, mostly splitting into thin laminæ; generally dull, with some pitch-like layers. Much fibrous coal-dust in the sample.

No. 1923—"*Coal, from A. Woodward's coal bank, on Barrett's Creek. Bed twenty-four to thirty inches thick. A low coal. By C. J. Norwood.*"

Sample evidently from an outcrop, considerably soiled with ferruginous dirt. Coal easily broken and split into quite thin laminæ, some of which present tarnished irised colors. Contains much fibrous coal and bright pyrites.

No. 1924—"*Coal, from Gaines' bank, near Fordsville. Bed four feet thick. Average sample by C. J. Norwood.*"

A firm splint coal, some of it pitch-like on the cross-fracture. Not much fibrous coal, but considerable fine granular pyrites. Some external ferruginous stain.

No. 1925—"*Coal, from H. Dooring's mine. About four miles east from Point Pleasant. Lower member four feet five inches thick. Collected by C. J. Norwood.*

A bright, pitch-black, firm coal, handsomely iridescent on some of the seams. Has very little fibrous coal and some fine granular pyrites between the laminæ.

No. 1926—"*Coal, from Henry Thompson's coal bank. One and three quarters of a mile from Elm Lick. A lower coal (H?). Sample from below the parting, three feet five inches thick. The whole bed, including the parting, four feet ten inches. Collected by C. J. Norwood.*"

A pitch-black coal, in very thin laminæ, with much fibrous coal of a reedy appearance. No apparent pyrites.

No. 1927—"*Coal, from Morton's coal bank, two miles northwest from Centretown. Bed from eight to nine feet thick, with a thin clay parting. Sample from the lower member four feet four inches to four feet seven inches thick. By C. J. Norwood.*"

A pitch-black, pure-looking coal. Iridescent on some of the seams. Not easily breaking into thin laminæ, with very little fibrous coal. Some pyritous and gypsum scales in the seams.

No. 1928—"*Coal, from Martin's coal bank, near Elm Lick. Coal H? From the lower member; not a fair sample, as it is from a new opening just begun. C. J. Norwood.*"

In quite thin laminæ, with fibrous coal and some granular pyrites between. Seems to have been much weathered. Is much stained with ferruginous clayey matter.

No. 1929—"*Coal, from Henry Davis' mine, about four miles east from Point Pleasant. Sample from the upper member three feet nine inches thick. By C. J. Norwood.*"

A pure-looking, pitch-black, firm coal. Not all easily breaking into thin laminæ. Has some fibrous coal and granular pyrites.

COMPOSITION OF THESE OHIO COUNTY COALS, AIR-DRIED.

	No. 1904.	No. 1905.	No. 1906.	No. 1907.	No 1908.	No. 1909.	No. 1910.	No. 1911.	No. 1912.	No. 1913.	No. 1914.	No 1915.	No. 1916.
Specific gravity	1.318	1.331	1.310	1.336	1.295	1.297	1.251	1.382	1.386	1.345	1.593	1.273	1.305
Hygroscopic moisture	3.80	2.70	4.40	4.10	5.00	5.90	5 54	5.10	4.80	3.50	2.20	5.30	6.54
Volatile combustible matters	36.66	35 24	38 20	34.36	36.74	33.80	35.66	30.70	33 70	36.30	27.80	45.70	37.92
Coke	59.54	62.06	57.40	61 54	58.26	60.30	58.80	64.20	61.50	60.20	70.00	49.00	55.54
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.46	37.94	42.60	38.46	41.74	39.70	41.20	35.80	38.50	39.80	30.00	51.00	44.46
Fixed carbon in the coke	52.00	53.62	49.94	51.24	55.66	56.90	56.20	54.24	52.26	50.92	35.28	45.00	51.54
Ash	7.54	8.44	7.46	10.30	2.60	3.40	2.60	9.96	9.24	9.28	34.72	4.00	4.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Spongy.	Spongy	Light spongy.	Pulverulent.	Dense spongy.	Light spongy.
Color of the ash	Light lilac-grey.	Lilac-grey	Light lilac-grey.	Lilac-grey	Light brown.	Buff.	Light buff	Light brownish lilac-grey.	Brownish lilac-grey.	Brownish lilac-grey	Dark brownish lilac-grey.	Lilac-grey	Light yellowish-brown
Per centage of sulphur	1.944	3.785	2.246	3.263	1.605	1.038	0.983	2.164	3.364	3.524	5.694	2.150	1.917

COMPOSITION OF THESE OHIO COUNTY COALS, AIR-DRIED—(Continued)

	No. 1917.	No. 1918.	No. 1919.	No. 1920.	No. 1921.	No. 1922.	No. 1923.	No. 1924.	No. 1925.	No. 1926.	No. 1927.	No. 1928.	No. 1929.
Specific gravity	1.295	1.384	1.340	1.356	1.357	1.380	1.413	1.310	1.310	1.282	1.348	1.321	1.411
Hygroscopic moisture	4.80	4.80	6.80	4.80	6.66	6.00	2.70	6.10	5.54	3.96	3.94	3.70	3.20
Volatile combustible matters	41.00	35.80	32.40	35.60	33.64	34.30	39.30	37.50	35.66	40.50	37.86	36.64	37.06
Coke	54.20	59.40	60.80	59.60	59.70	59.70	58.00	56.40	58.80	55.54	58.20	59.66	59.74
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	45.80	40.60	39.20	40.40	40.30	40.30	42.00	43.60	41.20	44.46	41.80	40.34	40.26
Fixed carbon in the coke	49.14	45.20	52.50	49.66	51.56	50.36	45.90	50.46	48.88	52.38	50.48	55.30	47.24
Ash	5.06	14.20	8.30	9.94	8.14	9.34	12.10	5.94	9.92	3.16	7.72	4.36	12.50
Total	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Spongy.	Spongy.	Light spongy.	Spongy.	Spongy.	Spongy.	Much inflated.	Much inflated.	Light spongy	Dense.	Dense.
Color of the ash	Dark lilac-grey.	Light lilac-grey.	Very light lilac-grey.	Light lilac-grey.	Light grey.	Grey-brown.	Greyish purplish-brown.	Light grey.	Dark lilac-grey.	Lilac-grey.	Lilac-grey.	Light purplish-brown.	Dark lilac-grey
Per centage of sulphur	2.356	3.015	2.109	3.180	2.768	4.307	7.959	3.002	4.199	1.407	3.128	1.241	6.809

These Ohio county coals are generally good, and some of them are very good; the ash and sulphur per centages of some of them, it will be seen, exceed the average; but none, except the one characterized as bituminous shale, is very seriously injured for all ordinary applications: even this might be utilized as fuel in its own vicinity.

The general correspondence between the specific gravity and ash per centage is still further exhibited in these analyses.

OHIO COUNTY LIMONITE IRON ORES.

No. 1930—"*Limonite Ore, from Alfred Ashby's land, on the waters of Walton Creek. Seems to be slightly magnetic? Collected by C. J. Norwood. Coal measures.*"

A porous, cellular, somewhat friable ore; generally of a deep-brown color, with blotches and thin laminæ of light ochreous and irregular portions of denser, fine granular, or specular ore, of a steel-blue color, which is slightly magnetic and gives a red streak.

No. 1931—"*Limonite, from Dooring's iron bank. Coal measures. Sampled for analysis by C. J. Norwood.*"

Composed of irregular laminæ; generally of a dark-brown color, with lighter, ochreous ore mixed and incrusting. Somewhat friable. Powder of a handsome bright yellow-ochre color.

No. 1932—"*Limonite, from same locality as preceding,*" *&c. &c.*

Resembles the preceding. Probably a little more dense.

No. 1933—"*Ochreous Limonite, from Mrs. Kate Inglehart's place, eight miles southwest of Hartford. Coal measures. Collected by C. J. Norwood.*"

A fine granular, friable ochre, of a handsome brownish-yellow color.

COMPOSITION OF THESE OHIO COUNTY LIMONITE IRON ORES, DRIED AT 212° F.

	No. 1930.	No. 1931.	No. 1932.	No. 1933.
Iron peroxide	75.845	55.357	56.972	18.676
Alumina	.837	9.656	1.148	2.481
Manganese oxide	not est	not est.	not est.	not est.
Lime carbonate	a trace.	a trace.	a trace.	a trace.
Magnesia	.176	.248	.176	.338
Phosphoric acid	.648	.287	.280	.073
Sulphuric acid	not est.	not est.	not est.	not est.
Combined water	9.273	8.860	8.920	6.152
Silicious residue	13.830	26.550	32.504	72.280
Total	100.609	100.958	100.000	100.000
Iron per centage	53.091	38.750	39.880	13.073
Phosphorus per centage	.283	.125	.177	.032
Sulphur per centage	not est.	not est.	not est.	not est.
Silica per centage	9.960	23.420	24.460	69.100

No. 1930 is a good iron ore, containing not more than the average proportion of phosphorus, which may be partly removed, in smelting, in combination with its large proportion of alumina, if sufficient lime be employed as the flux. Nos. 1931 and 1932, although containing much less iron, may be made available in mixture with other richer ores. But No. 1933 is too poor for iron production, and could only be employed as a pigment, or in mixture with very rich ores, to furnish silicious matter to aid in fluxing them.

OWEN COUNTY.

No. 1934—"GALENA, *from a vein about twenty-three inches thick, on Twin Creek. Sent by Thos. J. Jenkins, Esq., New Liberty.*"

A digging has been made more than eighty feet deep, and the vein gradually widens as it descends. The specimen sent was obtained about five feet below the surface. *Lower Silurian formation.*

The galena has some little zinc blende mixed with it, and has a gangue of baryta sulphate and calcareous spar (lime carbonate). It contains, of course, the usual per centage of lead, being a definite chemical compound of lead and sulphur; and, if found in sufficient quantities in the vein, for the

cheap production of lead, would be valuable; but in this region, where galena is very frequently found, mixed in large or small (but generally small) proportion with the baryta sulphate, which forms numerous veins in our "blue limestone," the prevalent idea is that there is a large quantity of silver in this shining ore. Indeed, companies have been formed, and much capital sunk in the opening and working of so-called silver mines in the baryta veins of our Lower Silurian limestone; with the usual result, that even the lead obtained and the spar sold would not repay the cost of the labor, while silver is not found.

The specimen above described was examined carefully for the presence of silver, in the wet way, with the result that no ponderable quantity of that metal could be separated from it. This has been the usual result of the analyses of the galenas of this region. They all appear to be remarkably poor in silver. The only practical question in relation to these metallic veins seems, therefore, to be, whether they can be profitably worked for the lead alone. The baryta sulphate, which is quite abundant in these veins, has not yet found a profitable application in any quantity.

No. 1935—"BARYTA SULPHATE; *massive.* (*Ponderous spar.*) *From the same locality as the above. Hunter's Mill. Twin Creek. Collected by C. J. Norwood.*"

This spar was analyzed by my son, Alfred M. Peter, mainly for the purpose of determining the proportion of strontium contained in it, with the following result:

COMPOSITION, DRIED AT 212° F.

Baryta sulphate	80.31
Strontia sulphate	17.05
Lime sulphate	.34
Iron peroxide	.15
Silica	.29
Loss, &c., &c.	1.86
Total.	100.00

The proportion of strontia sulphate is larger than was supposed. The presence of strontium in this spar corresponds

with its existence in association with barium in some of the saline waters of our State, as shown under the head of Clay and Meade counties in the present report.

OWSLEY COUNTY.

COALS.

No. 1936—"*Coal, from the mines of Steffee & Samuel. South Fork of Kentucky river, four miles above Boonesville, on the east bank of the river. Sample sent by Mr. J. T. Steffee, and analyzed at the request of the Governor. Bed three feet thick.*"

A good-looking splint coal. Iridescent on some of its surfaces; containing some bright pyritous scales, and showing marked reedy impressions on some of the laminæ.

No. 1937—"*Cannel Coal, owned by Steffee & Samuel. South Fork of Kentucky river,*" *&c., &c.* (*as above*).

A handsome cannel coal. Very tough. Jet-black and glossy on its cross fracture. Has no apparent pyrites.

COMPOSITION OF THESE OWSLEY COUNTY COALS, AIR-DRIED.

	No. 1936.	No. 1937.
Specific gravity	1.294	1.161
Hygroscopic moisture	2.10	0.50
Volatile combustible matters	35.24	59.70
Coke	62.66	39.80
Total	100.00	100.00
Total volatile matters	37.34	60.20
Fixed carbon in the coke	58.66	32.34
Ash	4.00	7.46
Total	100.00	100.00
Character of the coke	Spongy.	Dense.
Color of the ash	Light lilac-grey.	Light brown.
Per centage of sulphur	1.424	not det'd.

These coals are both remarkably good and pure of their kinds. The cannel coal exceeds the celebrated Haddock's cannel coal in volatile matters fully ten per cent., and equals the Breckinridge coal of Hancock county in its volatile combustible matters (see No. 1813, Cloverport Oil Company's coal), than which it has a smaller ash per centage. It greatly resembles this celebrated coal, but is purer. Should our petroleum wells run low, coals of this character will be again profitably available for the production of so-called coal oil, lubricating oils, and other paraffins, with the lighter hydrocarbons, now derived almost exclusively from the mineral oil. A greater economy in the manufacture of these from the cannel coal, and the profitable use of the gas and coke, which are simultaneously produced, may favor the competition of the coal distillates with those from the petroleum.

PERRY COUNTY.

COALS.

No. 1938—"*Coal, from Josiah Cobb's bank, near Hazard. Average sample taken from the upper part of the bed, the lower part not being uncovered. By P. N. Moore.*"

A pure, pitch-black splint coal, having very little fibrous coal between the laminæ, but with ferruginous stain and appearance of pyrites in parts.

No. 1939—"*Coal, from Campbell's bank. Mace's Creek. Sampled from near the outcrop; hence probably will give more ash than the coal further in. Collected by P. N. Moore.*"

A splint coal, very much weathered and soiled with dirt; hence the ash per centage is probably greater than that of the bed. The sample has much powdered (fibrous) coal in it; probably more than belongs to it.

No. 1940—"*Coal, from R. C. Combs' bank; below Hazard, on the North Fork of Kentucky river. Collected by P. N. Moore.*"

A pure-looking, pitch-black splint coal. Has some ferruginous stain on some of its seams, but very little fibrous coal or apparent pyrites.

No. 1941—"*Coal, from Logan's drift. Brashear Salt-works. Collected by P. N. Moore.*"

Resembles the preceding, but has no ferruginous stain.

No. 1942—"*Coal, from David Grigsby's bank. Lot's Creek. Bituminous coal, above the cannel coal. Collected by P. N. Moore.*"

Coal, breaking into thin laminæ, with but little fibrous coal or granular pyrites between them. Exterior of the lumps dull and much stained with ferruginous and clayey matters, as though they had been weathered, which probably may somewhat increase the ash per centage.

No. 1943—"*Coal, from the same bed as the next preceding. Lower part of the bed. The cannel coal. Collected by P. N. Moore.*"

Mostly tough, compact cannel coal, with a satiny lustre on its cross-fractured surfaces. Some pieces more readily separate into thin laminæ. The exterior surfaces are soiled with ferruginous and clayey matters, which will probably make the apparent ash per centage greater than that of the clean coal of the beds.

COMPOSITION OF THESE PERRY COUNTY COALS, AIR-DRIED.

	No. 1938	No. 1939	No. 1940	No. 1941	No. 1942	No. 1943
Specific gravity	1.289	1.370	1.303	1.288	1.274	1.290
Hygroscopic moisture	2.10	3.70	2.06	1.60	1.80	1.20
Volatile combustible matters	36.20	30.64	36.74	36.10	40.90	40.86
Coke	61.70	65.66	61.20	62.30	57.30	57.94
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	38.30	34.34	38.80	37.70	42.70	42.06
Fixed carbon in the coke	58.20	57.02	56.30	56.40	53.70	48.44
Ash	3.50	8.64	4.90	5.90	3.60	9.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Pulverulent.	Spongy.	Light spongy.	Light spongy.	Dense.
Color of the ash	Buff-grey.	Grey-buff.	Brownish-grey.	Light grey.	Brown-grey.	Light grey.
Per centage of sulphur	0.836	0.654	1.436	0.836	1.339	0.634

These Perry county coals are remarkably good, containing much less than the average quantity of sulphur, and leaving, generally, but a small amount of ash. With the exception of the cannel, they are semi-bituminous or splint coals, of the same character as the celebrated Block coal of Indiana. The coals of the eastern coal field of Kentucky, as yet measurably unknown and undeveloped, promise to be more valuable in the future than any in the State.

PULASKI COUNTY.

COALS.

No. 1944—"*Coal, from the Cumberland coal banks; mine owned by W. S. Brown and Wm. Owens; two miles south from the Cumberland river; nine miles from Rockcastle Springs; eighteen miles from Somerset. Sub-conglomerate coal. Bed forty inches thick, without a parting. Average sample taken fifty feet from the mouth of the mine. By John H. Talbutt.*"

318

A pure-looking coal; somewhat tough, with but little fibrous coal and some fine granular pyrites between the laminæ.

No. 1945—"*Coal, from Doolin coal bank; owned by Allen Jones; one mile from Cumberland river; ten miles from Rockcastle Springs. A sub-conglomerate coal. Average sample taken from the head of the drift, seventy-five feet from the mouth. By John H. Talbutt. Bed fifty-one inches thick, containing a good deal of pyrites in some places.*"

A pitch-black splint coal, with but little fibrous coal between the laminæ, but much pyrites.

COMPOSITION OF THESE PULASKI COUNTY COALS, AIR-DRIED.

	No. 1944.	No. 1945.
Specific gravity	1.357	1.357
Hygroscopic moisture	2.40	2.00
Volatile combustible matters	36.76	35.30
Coke	60.84	62.70
Total	100.00	100.00
Total volatile matters	39.16	37.30
Fixed carbon in the coke	50.24	52.94
Ash	10.60	9.76
Total	100.00	100.00
Character of the coke	Spongy.	Light spongy.
Color of the ash	Brownish-lilac-grey.	Dark lilac-grey.
Per centage of sulphur	2.494	3.565

These two samples resemble each other considerably. They are good and profitable coals, although their ash and sulphur per centages somewhat exceed the average.

No. 1946—"CHALYBEATE WATER, *from Rockcastle Springs. From a natural spring on the north side of Rockcastle river, near its margin, and below high-water level. Water said to*

come from a bed of shale; is confined in a box about eighteen inches in diameter, from which it flows in a half-inch stream. Brown-ochreous, ferruginous incrustation on the box. Sample collected by John H. Talbutt."

COMPOSITION OF THIS CHALYBEATE WATER IN 1000. PARTS.

Iron carbonate	0.0145		
Lime carbonate	.0438		Held in solution by carbonic acid.
Magnesia carbonate	.0148	= .0731	
Lime sulphate	.0029		
Magnesia sulphate	.0036		
Soda sulphate	.0531		
Sodium chloride	.0026		
Silica	.0128		
	0.1481		

The water contained 0.0930 per thousand, by weight, of free carbonic acid.

Although containing but a very small proportion of saline matters or of iron, this water may be not the less available in the treatment of many diseases. Indeed, some of the most celebrated mineral waters of the world are nearly pure water. The undoubted curative or restorative effects of such waters depend, not only on their depurative influence, when regularly taken in proper quantity, and the alterative influence of minute proportions of iron compounds or other ingredients present in them, but also on the exercise, change of scene, relaxation of mind, and regular diet and regimen, which are generally to be found at the watering-place. (See Whitley county for other chalybeate springs of this neighborhood.)

ROCKCASTLE COUNTY.

COALS.

No. 1947—"*Coal, from Myzner's and Myers' bank. Livingston. An inter-conglomerate coal. Average sample by A. R. Crandall; taken one hundred and fifty yards in entry No. 1. Average thickness of the bed twenty-eight inches.*"

A pure-looking, glossy-black splint coal. But little fibrous coal between the laminæ, and no apparent pyrites.

No. 1948—"*Coal, from same mine. Entry No. 2. Average Sample collected by A. R. Crandall.*"

Much like the preceding in appearance.

No. 1849—"*Coal, from Grisham's coal mine, near Livingston. First above the conglomerate. Upper 'brashy coal' bed; average thickness two feet. Average sample by C. J. Norwood.*"

A splint coal. Fibrous coal and much granular pyrites between its thin laminæ.

No. 1950—"*Coal, from same mine. From the lower nine inches of the two feet bed. Local name, 'Block coal.' By C. J. Norwood.*"

A deep-black, glossy coal, iridescent in parts. But little fibrous coal or pyrites apparent.

COMPOSITION OF THESE ROCKCASTLE COALS, AIR-DRIED.

	No. 1947.	No. 1948.	No. 1949.	No. 1950.
Specific gravity	1.318	1.357	1.327	1.374
Hygroscopic moisture	2.00	2.20	2.20	2.10
Volatile combustible matters	36.66	36.50	35.86	39.50
Coke	61.34	61.30	61.94	58.40
Total	100.00	100.00	100.00	100.00
Total volatile matters	38.66	38.70	38.06	41.60
Fixed carbon in the coke	51.94	51.70	54.94	49.86
Ash	9.40	9.60	7.00	8.54
Total	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Light spongy.	Spongy.	Spongy.
Color of the ash	Lilac-grey.	Dark lilac-grey.	Light chocolate.	Purplish-grey.
Per centage of sulphur	2.205	4.802	4.302	2.933

These coals greatly resemble, in general composition, those from near the Cumberland river, described under the head of Pulaski county.

No. 1951—"CLAY, *from Pine Hill coal mines. Rockcastle county. Collected by John H. Talbutt.*"

A light-grey plastic clay, mottled with ferruginous.

This was only examined for its proportion of alkalies. It was found to contain of potash = 3.083 per cent. of the dried clay (at 212°); soda = 0.524 per cent.

It therefore would not probably prove to be a very refractory clay.

No. 1952—"METALLIC IRON. *Brought by Mr. Jones, of Lexington.*"

Said to be from Holley farm, on the dividing ridge between Goose creek and Rockcastle river, head waters of Rockcastle river, near the line of Laurel county. It is similar to a specimen brought to the writer from near Manchester, Clay county, in 1854, by the late Daniel White. Said by both these individuals to be abundant on the surface. It is similar in appearance to some specimens obtained by Mr. C. J. Norwood and others from near Manchester, Clay county, and said to be abundant there.

It presents the appearance of medium fine-grained "mill iron;" is dark-colored; yields to the file, but is quite brittle, extending very little under the hammer. The surface of Mr. Jones' specimen was polished and treated with nitric acid; but while this produced a fine-radiated, Damascus-like appearance, no Widmanstattian figures were produced.

The pieces obtained all seem to be portions of a slab, about one and a half inches thick, the exterior surfaces of which have a coating about one sixteenth of an inch thick of oxide, which looks as though it had either been caused by heat or by a long exposure to the atmosphere.

It was found, on examination, to contain of carbon, about two to three per cent.; silicon, about one per cent.; a doubtful trace of copper, but no nickel.

The per centage of iron was not ascertained, nor was the analysis carried further.

The fact that so many pieces of this iron have been brought to the laboratory, and that so many persons bear testimony to its abundance on the surface in the region in question, is interesting. Is it a meteoric iron? If not, how

came it to be scattered over the ground at such a distance from iron furnaces? Persons in the part of the country where it is found might perhaps throw light on the subject.

WEBSTER COUNTY.

MINERAL WATERS.

No. 1953—"*Water, from the 'Sulphur Spring.' Sebree Springs. Collected by C. J. Norwood.*"

The water, when brought to the laboratory, had deposited a slight black sediment in the bottle, containing some iron sulphide, and had lost its sulphuretted hydrogen. It still contained free carbonic acid gas, the amount of which was not estimated. It gave a slight alkaline reaction. (Analyzed by my son, Alfred M. Peter.)

COMPOSITION IN 1000. PARTS OF THE WATER.

Iron and manganese oxides	0.007	Held in solution in the recent water by free carbonic acid.
Lime carbonate	.2178	
Magnesia carbonate	.0191	
Lime sulphate	.0017	
Magnesia sulphate	.0370	
Potash sulphate	.0042	
Soda sulphate	.1433	
Sodium chloride	.2700	
Silica	.0176	
Organic matters and loss	.0070	
Total saline matters	0.8358	Dried at 212° F.

Unquestionably a very good saline sulphur water, containing traces of iron and manganese. Part, if not all of the organic matters, may have been derived from the cork.

No. 1954—"*Water, from the 'Chalybeate Spring.' Sebree Springs, &c., &c. Collected by C. J. Norwood. This spring is frequented by people from Henderson and Evansville, &c., and has considerable local reputation.*"

Most of the iron had been deposited in the bottle as a brownish sediment; but this was re-dissolved, analyzed, and calculated into the whole amount in the following report of the analysis. This analysis was also made by Alfred M. Peter.

COMPOSITION IN 1000. PARTS.		
Iron carbonate	0.0297	Held in solution by carbonic acid.
Manganese carbonate	trace.	
Lime carbonate	.0247	
Magnesia carbonate	.0179	
Lime sulphate	.0218	
Potash sulphate	.0042	
Soda sulphate	.0205	
Sodium chloride	.0026	
Silica	.0010	
Organic matters and loss	.0066	
Total saline matters	0.1290	Dried at 212° F.

The proportion of free carbonic acid in the water was not determined, as doubtless much of it had escaped in transportation. There can be no doubt that it may be made available in the treatment of many maladies, under proper medical advice.

WEBSTER COUNTY SOILS.

No. 1955—"*Virgin Soil. Woods pasture. Farm of Mr. Bowland, near Madisonville. Forest growth: elm, black walnut, red and white oak, &c., &c. Underlying rock; sandstone. Collected by C. W. Beckham.*"

Dried soil of a brownish-buff color; contains no gravel. The silicious residue contained a few small rounded grains of clear quartz.

No. 1956—"*Surface Soil, from a field twelve to fifteen years in cultivation in corn and tobacco; from same farm and near the same locality as the above. Collected by C. W. Beckham.*"

Dried soil of a dark brownish-buff color; contains no gravel. Silicious residue contains a few small rounded quartz grains.

No. 1957—"*Subsoil of the next preceding,*" *&c., &c.*

Dried soil of a buff color; contains no gravel. Silicious residue like the preceding.

COMPOSITION OF THESE WEBSTER COUNTY SOILS, DRIED AT 212° F.

	No. 1955	No. 1956	No. 1957
Organic and volatile matters	4.010	2.975	3.575
Alumina and iron and manganese oxides	4.064	3.997	7.289
Lime carbonate	.145	.220	.145
Magnesia	.178	.160	.124
Phosphoric acid	.071	.118	.061
Sulphuric acid	not est.	not est.	not est.
Potash	.288	.104	.135
Soda	.055	.152	.415
Sand and insoluble silicates	91.350	91.490	88.015
Water, expelled at 380° F.	.400	.225	.500
Loss	....	.559	....
Total	100.561	100.000	100.259
Hygroscopic moisture	1.500	1.375	2.105
Potash in the insoluble silicates	1.461	1.534	1.619
Soda in the insoluble silicates	.759	.698	.912
Character of the soil	Virgin soil.	Cultivated soil.	Subsoil.

These soils are good for sandstone soils, and can be made quite productive by proper management and the judicious use of manures, of which phosphatic fertilizers are indicated. They promise a considerable durability in the considerable proportions of alkalies contained in their insoluble silicates.

WHITLEY COUNTY.

MINERAL WATERS.

No. 1958—"*Chalybeate Water. L. Renfro's. Cumberland Falls. Spring about one hundred yards below the falls, on the north side of the river. From just above the Lower Conglomerate. The sandstone from which it flows is near the level of high water in the river. The water is contained in a small rock basin. It forms an ochreous deposit, and contains some flocculent matter. There are other similar sources in the neighborhood. Collected by John H. Talbutt.*"

No. 1959—"*Chalybeate Water. L. Renfro's. Cumberland Falls. Spring on the south side of the river, just under the falls of Eagle Creek, and about three hundred yards below the falls; above high water. This water deposits an ochreous*

sediment also. It issues from the Conglomerate rock in a wooden spile. Collected by J. H. Talbutt."

COMPOSITION OF THESE CHALYBEATE WATERS, IN 1000. PARTS OF THE WATER.

	No. 1958.	No. 1959.	
Iron and manganese carbonates . .	0.0082	0.0072	Held in solution in the water by carbonic acid.
Lime carbonate	.0476	.0405	
Magnesia carbonate	.0327	.0266	
Silica	.0007	not det'd.	
Lime sulphate.	.0141	.0019	
Magnesia sulphate	.0060	.0060	
Iron and alumina sulphates	.0038	.0053	
Potassium chloride.	not est.	not est.	
Sodium chloride	not est.	.0031	
Silica	.0217	.0176	
Undetermined and loss	.0432	.0088	
Total dry saline contents	0.1860	0.1200	In 1000. parts of the water.

The amount of free carbonic acid in these chalybeate waters was not determined. The judicious use of these waters could no doubt be made quite beneficial in the treatment of many maladies.

No. 1960—"*Bituminous Shale, or impure Coal; from Louis Renfro's land; Cumberland Falls. Bed fifteen inches thick; one hundred and sixty yards below the falls, and one hundred and eighty feet above the river, and about the same distance from it. In massive sandstone; forty feet thick, immediately above. Inter-conglomerate. Collected by John H. Talbutt.*"

This shale, air-dried, gave off 2.84 per cent. of *hygroscopic moisture* at 212° F., and 27.16 per cent. of *volatile combustible matters*, leaving 70.00 per cent. of *dense coke*, which contained 26.60 per cent. of *ash*. The *fixed carbon* thus amounted to 43.40 per cent. Its per centage of sulphur was found to be 2.562; so that it may be made available for fuel, &c., in its vicinity, notwithstanding its large proportion of earthy matter.

WHITLEY COUNTY SOILS.

No. 1961—"*Soil; uncultivated; from the bluff opposite Rockcastle Springs. On the Conglomerate. Collected by John H. Talbutt.*"

Dried soil of a light umber-grey color. Contains a few small fragments of ferruginous sandstone. The bolting-cloth separated from its silicious residue about one fourth of its bulk of fine, rounded, colorless quartz grains.

No. 1962—"*Virgin Soil; from the top of King's Mountain. Eight hundred feet above the valley. (U. S. Coast Survey Station.) Collected by C. W. Beckham.*"

Dried soil of a brownish-grey color; contains about twenty to thirty per cent. of small shaly ferruginous sandstone fragments. The bolting-cloth separated from its silicious residue a large proportion of fine, rounded grains of hyaline quartz, and greyish, partly decomposed silicates, and a few mica scales.

COMPOSITION OF THESE WHITLEY COUNTY SOILS, DRIED AT 212° F.

	No. 1961.	No. 1962.
Organic and volatile matters	3.075	4.265
Alumina and iron and manganese oxides	3.429	2.695
Lime carbonate	.115	.110
Magnesia	.080	.084
Phosphoric acid	.061	.140
Sulphuric acid	.008	not est.
Potash	.194	.052
Soda	.164	not est.
Sand and insoluble silicates	91.105	91.465
Water, expelled at 380° F.	1.500	.782
Total	99.731	99.593
Hygroscopic moisture	1.200	0.950
Potash in the insoluble silicates	.692	0.989
Soda in the insoluble silicates	.120	.291
Character of the soil	Virgin soil.	Virgin soil.

Better soils than might have been expected from their location.

WOLFE COUNTY.

COALS.

No. 1963—"*Coal, from C. M. Hanks' bank. Compton. Bed twenty-eight inches thick; without parting. Sample by A. R. Crandall.*"

A pure-looking, pitch-black coal. Has but little fibrous coal. Some shining pyritous scales in the seams.

No. 1964—"*Cannel Coal, or Bituminous Shale. James F. Ely's. Gilmore Creek. Sample by P. N. Moore.*" Hand specimen.

A dull-looking cannel coal, breaking with difficulty. No appearance of fibrous coal or pyrites. Small glimmering micaceous scales abundant in it.

No. 1965—"*Cannel Coal. John W. Faukner's. Stillwater Creek. Collected by P. N. Moore.*" Not an average sample.

A dull-black, pure-looking coal, with a large conchoidal fracture.

No. 1966—"*Coal, from Hobb's bank, on Benjamin Baker's land; four and a half miles from Compton. Collected by P. N. Moore.*"

A pure-looking splint coal. A little fibrous coal and fine granular pyrites between some of its laminæ. One piece contained some particles of light reddish-brown *resin.*

COMPOSITION OF THESE WOLFE COUNTY COALS, AIR-DRIED.

	No. 1963.	No. 1964.	No. 1965.	No. 1966.
Specific gravity	1.336	1.434	1.383	1.294
Hygroscopic moisture	3.74	1.30	1.16	3.50
Volatile combustible matters	35.52	41.40	44.58	35.20
Coke	60.74	57.30	54.26	61.30
Total	100.00	100.00	100.00	100.00
Total volatile matters	39.26	42.70	45.74	38.70
Fixed carbon in the coke	52.64	28.20	32.76	56.70
Ash	8.10	29.10	21.50	4.60
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Pulverulent.	Pulverulent.	Spongy.
Color of the ash	Lilac-grey.	Nearly white.	Light lilac-grey.	Lilac-grey.
Per centage of sulphur	2.466	0.846	0.530	1.189

The so-called cannel coals contain so much earthy matter that they might (one or both) be properly called bituminous shales. They are remarkable, however, for the large proportion of volatile combustible matters they yield; and hence may be made available, if the petroleum production fails, in the manufacture of the coal oil and other hydrocarbons, &c., which are now so extensively used. They will make quite good fuel, notwithstanding their large ashy residue. Coal No. 1966 is exceptionally pure and good, and No. 1963 is also quite a good coal.

TABLE I. SOILS, SUBSOILS, &c., DRIED AT 212° F.

Number in Report.	County.	Organic and volatile matters.	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and insoluble silicates.	Water expelled at 380° F.	Water expelled at 212° F.	Potash in the insoluble silicates.	Soda in the insoluble silicates.	Remarks.
1677	Bell	4.700	4.817	0.190	0.338	0.093	not est.	0.164	0.115	89.390	0.600	1.825	2.568	0.389	J. Turner's; val. of Big Yel. Cr.; vir. s.
1678	Bell	5.575	4.015	.190	.067	.220	not est.	.160	.217	88.875	.775	2.550	.735	.018	J. Turner's; old field soil.
1679	Bell	2.600	1.710	.115	.045	.125	not est.	.056	.006	93.940	.900	1.350	.850	.082	J. Turner's; subsoil.
1680	Bell	5.725	4.339	.065	.050	.096	not est.	.068	.035	89.390	.650	1.800	.568	.119	J. Turner's; virgin soil (foot-hills).
1681	Bell	2.750	4.137	.065	.042	.073	not est.	.106	.032	92.090	.885	.875	.713	.137	J. Turner's; subsoil.
1682	Bell	5.050	3.557	.265	.131	.093	not est.	.212	. . . .	90.215	.750	1.875	.347	.167	Cultivated field soil.
1683	Bell	1.800	2.474	.115	.060	.061	not est.	.086	.014	95.115	.750	.850	.501	.216	Cultivated subsoil.
1684	Bell	11.565	4.015	.145	.093	.125	not est.	.139	.074	84.040	.035	3.700	.583	.090	Virgin soil; top of Brison Mt.
1685	Bell	5.750	4.662	.145	.079	.108	not est.	.131	.039	88.540	.900	2.275	.717	.150	Subsoil; top of Brison Mt.
1686	Bell	4.050	4.197	.095	.066	.093	not est.	.128	not est.	90.440	.750	1.475	1.387	.213	Virgin soil; Yellow Creek Valley.
1687	Bell	5.925	8.840	.230	.052	.124	not est.	.139	.085	83.140	1.100	2.450	2.507	.344	Old field; Big Creek Valley.
1688	Bell	4.850	8.120	.095	.088	.093	not est.	.191	.117	86.040	.750	1.875	2.275	.251	Old field; subsoil.
1689	Bell	5.525	7.339	.095	.088	.061	not est.	.143	.063	85.140	1.200	2.225	2.362	.273	Old field; Big Yellow Creek Valley.
1690	Bell	4.725	7.013	.095	.088	.077	not est.	.243	. . . .	87.125	1.000	1.900	2.351	. . . .	Old field; subsoil Big. Yel. Cr. Valley.
1691	Bell	3.500	2.913	.290	.070	.093	.007	.158	.050	92.090	1.100	1.150	.496	.169	Old field; foot of Cumberland range.
1692	Bell	2.450	2.815	.275	.044	.125	.003	.203	.013	92.040	1.050	1.175	.674	.186	Old field; subsoil, ft of Cumb'd range.
1693	Bell	4.125	5.990	.225	.080	.125	.007	.109	.177	87.590	1.450	1.500	1.831	.561	Cultivated field; foot-hills.
1694	Bell	4.025	6.997	.225	.081	.093	.007	.368	. . . .	86.815	1.250	1.515	1.964	.348	Cultivated field; subsoil, foot-hills.
1695	Bell	7.175	9.626	.265	.155	.189	.007	.429	.190	80.040	2.075	2.500	2.519	.303	Old field; Big Yellow Creek Valley.
1696	Bell	5.675	12.816	.115	.322	.294	.013	.443	. . . .	78.240	2.025	2.525	2.640	.464	Old field; subsoil, Big Yel. Cr. Valley.
1723	Christian . . .	4.200	4.810	.065	.155	.125	not est.	.135	. . . .	89.940	.475	1.725	.925	.434	Virgin woodland soil (sandstone).
1724	Christian . . .	4.360	6.467	.125	.151	.068	not est.	.176	.261	88.710	.500	1.740	.980	.479	Cultivated soil (for 15 years).
1725	Christian . . .	3.135	9.310	.120	.139	.150	not est.	.083	.116	86.290	.375	1.900	1.131	.561	Subsoil of preceding.
1726	Christian . . .	3.300	3.922	.095	.115	.038	not est.	.121	.172	91.850	.250	.925	1.462	.569	Virgin soil.
1727	Christian . . .	4.330	6.402	.220	.106	.108	not est.	.247	.153	87.925	.325	1.500	1.457	.875	Old field soil.
1728	Christian . . .	4.065	12.155	.160	.164	.080	not est.	.637	.084	81.890	.450	2.800	1.367	1.044	Subsoil.
1729	Christian . . .	5.165	5.540	.270	.178	.070	not est.	.385	. . . .	88.615	.595	1.710	1.669	.478	Virgin soil (compact limestone).
1730	Christian . . .	4.065	4.618	.270	.124	.042	not est.	.256	. . . .	88.915	.445	1.590	1.642	.605	Old field soil.
1731	Christian . . .	3.600	11.193	.295	.142	.093	not est.	.457	. . . .	83.645	.400	3.000	1.516	.662	Subsoil.
1732	Christian . . .	2.625	4.036	.130	.097	.124	not est.	.121	.125	92.625	.450	1.050	1.421	.575	Virgin soil (sandstone).
1733	Christian . . .	2.925	5.992	.170	.153	.093	not est.	.125	. . . .	89.755	.550	1.365	1.166	.420	Old field soil (sandstone).
1734	Christian . . .	2.775	9.052	.070	.156	.108	not est.	.174	. . . .	86.575	.600	2.165	1.368	.461	Subsoil (sandstone).
1735	Christian . . .	4.675	4.127	.190	.167	.108	not est.	.260	. . . .	89.765	.725	1.600	1.304	.545	Virgin soil (limestone).
1736	Christian . . .	3.115	5.884	.270	.151	.086	not est.	.210	. . . .	89.815	.550	1.400	1.263	.325	Old field soil (limestone).
1737	Christain . . .	3.500	12.727	.295	.232	.108	not est.	.707	. . . .	81.890	.750	3.135	. . . .	. . . .	Subsoil (limestone).
1750	Daviess	5.475	6.174	.120	.016	.141	not est.	.134	.301	86.605	.975	1.775	.855	.581	Virgin soil; hill top.
1751	Daviess	3.150	7.065	.245	.034	.125	not est.	.053	. . . .	88.390	.925	1.515	1.122	.709	Old field; hill top.
1752	Daviess	2.715	10.654	.095	.021	.061	not est.	.244	. . . .	85.415	.910	1.565	1.386	.680	Subsoil; hill top.
1753	Daviess	5.875	5.349	.220	.044	.086	not est.	.407	. . . .	86.590	1.450	1.700	.975	.403	Virgin soil; upland.
1754	Daviess	2.550	5.502	.085	.133	.083	not est.	.265	. . . .	90.890	.600	.875	1.396	.729	Old field; upland.
1755	Daviess	3.175	12.958	.075	.080	.102	not est.	.475	.075	82.300	1.175	3.500	1.457	.639	Subsoil; upland.

1779	Fayette	4.676	9.570	0.230	0.140	0.444	not est	0.287	not est.	82.860	1.824	2.165	1.274	0.211	Woodland pasture (blue grass) soil.
1780	Fayette . . .	3.085	10.445*	.220	.140	.540	not est.	.343	.192	83.260	1.234	1.965	1.314	.583	Subsoil to same.
1781	Fayette	7.800	12.286	1.145	.394	.364	not est.	.735	.084	76.690	1.300	2.975	.718	.200	Virgin open pasture; blue grass soil.
1782	Fayette	4.410	14.427	.545	.340	.358	not est.	.402	.301	77.440	.925	3.135	.910	.212	Subsoil to same.
1783	Fayette	4.400	19.921	.130	.376	.364	not est.	.755	. . . .	72.540	1.200	3.525	.644	.167	Under clay of same.
1809	Greenup. . . .	5.590	12.357	.045	.366	.083	.003	.433	.023	79.500	1.250	1.900	2.301	.509	Vir soil; woods; hill top; Wh. Oak Cr.
1810	Greenup. . . .	5.600	15.693	.070	.375	.147	trace.	.474	.305	76.060	.950	2.235	2.829	.368	Subsoil to same.
1811	Greenup. . . .	4.375	7.060	.270	.083	.115	.027	.098	.068	86.890	1.100	1.150	1.220	.520	Cultivated field; Valley Wh. Oak Cr.
1812	Greenup. . . .	3.790	6.656	.745	.067	.109	.033	.193	.163	87.665	.910	1.000	.817	.380	Subsoil to same.
1837	Hopkins . . .	3.950	5.845	.125	.088	.080	not est.	.193	. . . .	88.015	1.375	1.750	1.686	.425	Virgin soil; woods; sandstone.
1838	Hopkins . . .	3.900	5 936	.235	.137	.099	not est.	.086	.145	88.115	1.150	1.600	1.528	.371	Cultivated field; sandstone.
1839	Hopkins . . .	3.100	10.321	.115	.035	.064	not est.	.354	. . . .	84.665	1.050	2.600	1.149	.621	Subsoil of same.
1840	Hopkins . . .	5.895	5.649	.385	.142	.061	not est.	.348	.103	86.590	.625	1.580	1.336	.604	Vir. soil; w'ds; Morton's Gap; sandst'e.
1841	Hopkins . . .	4.000	6.153	.245	.092	.032	not est.	.300	.213	89.195	.420	1.225	1.272	.588	Old fi'd soil; Morton's Gap, sandstone.
1842	Hopkins . . .	3.080	7.224	.245	.095	.061	not est.	.498	.235	88.415	.550	1.335	1.236	.621	Subsoil of same.
1843	Hopkins . . .	7.125	6.322	.395	.162	.163	not est.	.325	.020	85.200	.875	1.775	1.152	.493	Vir. soil, near Nortonsville; sandstone.
1844	Hopkins . . .	3.185	5.155	.120	.124	.080	not est.	.292	.186	91.455	.430	.730	1.163	.388	Old field, near Nortonsville; sandstone.
1845	Hopkins . . .	3.815	10.090	.145	.269	.045	not est.	.518	.251	85.160	.685	2.160	1.247	.488	Subsoil of same.
1852*a*	Knox	3.453	5.456	.100	.158	.179	not est.	.125	.576	89.115	.741	.815	1.648	.130	Vir. soil; foot of Pt. Hill K'bs; s'dst'e.
1852*b*	Knox	4.374	8.781	.120	.158	.104	not est.	.261	not est.	85.165	.621	.900	1.648	.446	Old fi'd soil; f't of Pt. Hill K'bs; s'dst'e.
1852*c*	Knox	5.658	7.825	.095	.158	.185	not est.	.467	not est.	84.765	.909	1.025	2.320	.546	Vir. soil; top of Paint Hill Knobs.
1852*d*	Knox	2.800	2.835	.045	.016	.055	not est.	.112	.021	93.790	.525	.950	.399	.235	Virgin soil; Cumberland R. Valley.
1852*e*	Knox	2.765	1.904	.130	.029	.061	not est.	.094	not est.	94.530	.535	.435	.409	.150	Old fi'd soil, same locality as next above.
1852*f*	Knox	1.750	3.644	.045	.025	.031	not est.	.130	not est.	93.215	1.675	.435	.718	.119	Subsoil of same.
1853	Laurel	6.110	5.298	.110	.011	.077	not est.	.229	.149	87.330	1.100	.865	.843	.171	Virgin soil (sandstone).
1854	Laurel	3.625	4.882	.130	.025	.083	not est.	.312	.268	90.230	.725	.550	.661	.211	Old field soil, same locality.
1855	Laurel	2.450	5.719	.145	.016	.071	not est.	.110	.228	90 780	.400	.575	.892	.214	Subsoil of the next above.
1856	Laurel	5.990	7.339	.070	.124	.096	not est.	.217	. . . .	84.415	1.075	1.535	.939	.400	Virgin soil near London (sandstone).
1857	Laurel	3.475	7.361	.120	.053	.099	not est.	.074	. . . .	87.740	.675	.800	.862	.623	Old field soil (same locality).
1858	Laurel	3.740	9.385	.110	.075	.100	not est.	.447	. . . .	85.365	.725	1.425	.975	.575	Subsoil of next preceding.
1870	Lewis	3.325	10.965	.125	.266	.125	trace.	.501	.116	83.465	1.025	3.000	1.843	1.036	From Ohio Bottom.
1871	Lewis	2.665	8.995	trace.	.092	.125	.015	.387	.128	86.365	.685	2.225	1.233	.868	Subsoil of same.
1872	Lewis	4.425	9.545	.180	.208	.205	.050	.462	.134	83.100	1.725	2.935	1.138	.954	Old field soil; back of Ohio Bottom.
1903*a*	Muhlenburg . .	3.325	4.137	.345	.176	.189	trace.	.145	not est.	90.215	1.222	1.800	1.339	.716	Virgin soil (A. Stroud's farm).
1903*b*	Muhlenburg . .	1.052	3.548	.006	.167	.102	trace.	.167	not est.	94.340	1.050	.775	1.091	.564	Subsoil of same (A. Stroud's farm).
1903*c*	Muhlenburg . .	1.242	3 749	.145	.122	.121	trace.	.255	.477	93.140	1.242	.965	1.113	.474	Old field soil of same (sandy shale).
1955	Webster. . . .	4.010	4.004	.145	.178	.071	not est.	.288	.055	91.350	.400	1.500	1.461	.759	Vir. soil; woods pasture near Madis'v'e.
1956	Webster. . . .	2.975	3.997	.220	.160	.118	not est.	.104	.152	91.490	.225	1.375	1.534	.698	Cultivated field (same locality).
1957	Webster. . . .	3.575	7.289	.145	.124	.061	not est.	.135	.415	88.015	.500	2.105	1.619	.912	Subsoil of same.
1961	Whitley	3.075	3.429	.115	.080	.061	.008	.194	.164	91.165	1.500	1.200	.692	.120	Virgin soil (on bluff); conglomerate.
1962	Whitley	4.265	2.695	.110	.084	.140	not est.	.052	. . . .	91.465	.782	.950	.989	.291	Virgin soil; top of King's Mountain.

*Containing: of alumina 6.093, iron peroxide 4.330, and manganese oxide 0.021 per cent.

TABLE II. COALS, AIR-DRIED.

Number in Report.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Fixed carbon in the coke.	Ash.	Character of the coke.	Color of the ash.	Per centage of sulphur.	Remarks.
1667	Bell	1.276	1.90	37.50	60.60	39.40	57.90	2.70	Light spongy	Light-brown	1.519	Abram Lock's coal, Straight Creek.
1668	Bell	1.262	1.00	43.60	55.40	44.60	47.80	7.60	Dense spongy	Buff-grey	.590	Cannel coal; Col. Eves', Stony Creek.
1669	Bell	1.346	1.80	35.50	62.70	37.30	52.20	10.50	Light spongy	Very light grey	.956	Hignite coal; Branch of Yellow Creek, upper bed.
1670	Bell	1.290	2.04	36.64	61.32	38.68	58.02	3.30	Light spongy	Light lilac-grey	.736	Hignite coal; Branch of Yellow Creek, middle bed.
1671	Bell	1.277	2.96	35.28	61.76	38.24	59 40	2.36	Light spongy	Brownish-grey	.420	Hignite coal; Branch of Yellow Creek, lower bed.
1672	Bell	1.360	1.02	37.76	61.22	38.78	48 22	13.00	Light spongy	Lilac-grey	1.670	From Little Clear Creek.
1673	Bell	1.325	1.70	38.90	59.34	40.66	52.54	6.80	Light spongy	Lilac-grey	2.027	From Little Clear Creek.
1674	Bell	1.344	1.26	33.96	64.78	35.22	55.42	9.36	Light spongy	Light lilac-grey	2.672	From Fork Ridge, Stony Creek.
1675	Bell	1.282	1.36	35.80	62.84	37.16	59.54	3.30	Light spongy	Buff-grey	.975	Jas. Barnett's, Clear Fork.
1676	Bell	not est	1.50	37.94	60.50	39.44	58.40	2.16	Light spongy	Brownish-buff	1.038	Jas. Barnett's, Clear Fork, market sample.
1702	Breathitt	1.405	3.30	31.44	65 26	34 74	49.76	12.50	Dense friable	Pinkish-grey	.991	Roberts' bank, Troublesome Creek, bituminous part.
1703	Breathitt	1.280	3.40	43.40	53.20	46.80	46.96	6.24	Friable	Light buff-grey	.630	Roberts' bank, Troublesome Creek, cannel part.
1704	Breathitt	1.290	2.20	39.20	58.60	41.40	51.14	7.46	Spongy	Lilac-grey	2.525	Roberts' bank, Troublesome Creek, middle part.
1705	Breathitt	1.265	1.30	47.00	51.70	48.30	44.40	7.30	Dense	Brownish-grey	1.574	Haddock's cannel coal, Troublesome Creek.
1706	Breathitt	1.360	1.60	43.20	55.20	44.80	33.80	21.40	Pulverulent	Light-buff	2.549	Johnson's cannel coal, Frozen Creek.
1707	Breathitt	1.180	1.20	58.80	40.00	60.00	35.30	4.70	Dense	Light grey-buff	not est	Johnson's cannel coal, Frozen Creek.
1708	Breathitt	1.300	2.50	41.10	56.40	43.60	49.22	7.18	Light spongy	Dark lilac	.818	Johnson's cannel coal, Frozen Creek.
1709	Breathitt	1.328	2.10	43.10	54.80	45.20	43.36	11.44	Spongy	Light grey	4.609	Cannel coal; A. Little's, Quicksand Creek.
1710	Breathitt	1.398	2.78	35.52	61.70	38.30	44.94	16.76	Dense spongy	Light lilac-grey	1.423	Jackson Wells' coal, Troublesome Creek.
1711	Breathitt	1.280	.94	52.38	46.68	53.32	35 54	11.14	Dense	Light lilac-grey	1.423	Cannel coal, George's Creek.
1712	Breathitt	1.290	4.90	35.30	59.80	40.20	55.50	4.30	Spongy	Light grey	3.153	Simon Holland's coal.
1713	Breathitt	1.290	2.76	36.68	60.56	39.44	56.50	4.03	Light spongy	Light yellowish-grey	.865	Wolf Creek bank coal.
1714	Breathitt	1.297	3.56	33.56	62.88	37.12	58 38	4.50	Light spongy	Light lilac-grey	1.381	Wm. Spencer's coal, North Fork of Kentucky River.
1719	Christian	1.307	4.6	31.94	63.46	36.54	54.36	9.10	Dense	Light lilac-grey	1.469	Coal I, Coalton banks.
1720	Christian	1.332	5.10	32.50	62.40	37.60	55.70	6.70	Very dense	Light lilac-grey	1.277	Coal L, two miles south of Petersburg.
1721	Christian	1.396	3.70	32.50	63.74	36.26	50.04	13.70	Light spongy	Greyish-brown	3.710	Coal J, at Petersburg Station, St. L. & S. E. R. R.
1742	Clinton	1.329	1.50	37 74	60.70	39.30	50.20	10.50	Light spongy	Light lilac-grey	2.911	Conglomerate main coal, Cumberland mines.
1757	Daviess	1.323	6.20	30.20	57.60	42.40	50.90	6 70	Light spongy	Lilac-grey	1.519	Coal 2, Montgomery's mine.
1758	Daviess	1.340	4 10	38.50	57.40	42.60	51.00	6.40	Spongy	Lilac-grey	1.538	Coal D, Dutch mine.
1759	Daviess	1.318	5.80	35.06	59.14	40.86	50.40	8.74	Light spongy	Light lilac-grey	3.985	Coal D, Iron Harbor mines.
1760	Daviess	1.337	5.12	34.72	60.16	39.84	51.44	8.72	Light spongy	Light lilac-grey	3.513	Coal D, Dean's mine.
1761	Daviess	1.285	6.20	41.90	51.90	48.10	47.40	4.50	Light spongy	Grey-lilac	3.743	Coal from Duncan's bank, near Knottsville.
1784	Floyd	1.289	3.20	38.80	58.00	42.00	55.04	2.96	Light spongy	Light chocolate	2.318	Coal from Snipe's bank, Abbott's Creek.
1785	Floyd	1.274	2.50	40.80	56 70	43.30	53.40	3.24	Light spongy	Light grey	1.895	Coal from Harris' bank, Muddy Creek.
1786	Floyd	1.307	2.50	38.56	58.94	41.06	53.44	5.50	Spongy	Light lilac-grey	1.915	Coal from Hatcher's bank, Abbott's Creek.
1787	Grayson	1.343	6.50	30 04	63.46	36.54	55.54	7.92	Quite dense	Light lilac-grey	1.972	Coal from South or Allen bank, Falls of Rough Creek.
1795	Greenup	1.347	4.24	34.76	61.00	39 00	48.70	12.30	Spongy	Light lilac-grey	1.601	Turkey Lick coal.
1796	Greenup	1.331	4.00	37.70	58.30	41.70	51.60	6.70	Dense spongy	Lilac-grey	2.645	Coal 3, Turkey Lick, Pennsylvania Furnace.
1797	Greenup	1.280	4.56	36.68	58.76	41.24	52.40	6 36	Light spongy	Very light lilac-grey	.682	Turkey Lick coal mines, main entry
1798	Greenup	1.332	4.60	34.80	60.60	39.40	51.00	9.60	Dense spongy	Very light lilac-grey	.667	Turkey Lick coal, old entry.

1799	Greenup. . . .	1.384	4.22	30.10	65.68	34.32	53.68	12.00	Friable	Light lilac-grey . . .	.925	Raccoon Furnace coal.
1800	Greenup. . . .	not est	19.20		80.80	19.2	75.10	5.70	. . . . .	Nearly white	.666	Coke from Coal 3; Turkey Lick coal, Hunnewell Furn.
1813	Hancock . . .	1.213	1.30	59.60	39.10	60.90	27.00	12.10	Dense; friable. . .	Light grey-brown . .	1.890	Cannel coal; Cloverport Oil Company coal, entry No. 12.
1814	Hancock . . .	1.357	5.12	36.20	58.60	41.40	47.60	11.00	Dense.	Lilac-grey	4.038	Hancock Coal Company mines.
1815	Hancock . . .	1.353	5.40	34.80	59.80	40.20	49.30	10.50	Spongy	Light brownish-grey.	2.398	Milton Lawson's bank, Lead Creek.
1816	Hancock . . .	1.323	3.50	43.40	53.10	46.90	45.56	7.54	Light spongy . . .	Purplish chocolate . .	4 155	Robert Estes' bank, back of Lewisport.
1817	Hancock . . .	1.289	4.80	38.90	56.30	43.70	50.06	6.24	Light spongy . . .	Light brownish-grey.	2.316	Jas. Mason's bank, between Hawesville and Lewisport.
1818	Hancock . . .	1.401	4.50	37.60	57.90	42 10	47.46	10.44	Dense spongy . . .	Light chocolate . . .	7 809	Colbert's bank, near Lewisport.
1819	Hancock . . .	1.336	5.20	38.70	56.10	43.90	48.50	7.60	Dense spongy . . .	Light lilac-grey . . .	2.266	Bergenroth's bank, near Old Reverdy mines.
1820	Hancock . . .	1.308	7.46	33.14	59.40	40.60	55.20	4.20	Dense spongy . . .	Light grey.	1.368	John C. Schafer's bank, Blackford Creek.
1821	Hancock . . .	1.292	5.10	41.20	53.70	46.30	46.60	7.10	Light spongy . . .	Light lilac-grey . . .	3.331	Breidenbach's bank, Lead Creek.
1822	Hancock . . .	1.268	3.30	39.00	57.70	42.30	50.50	7.20	Light spongy . .	Brownish-grey	3.373	Davidson bank, near Hawesville.
1823	Hancock . . .	1.292	6.00	37 80	56.20	43.80	48.70	7.50	Spongy	Greyish-lilac.	3.180	R. S. Lanum's bank, near Hawesville.
1824	Harlan	1.516	1.40	34.60	64.00	36.00	39.40	24.60	Dense.	Chocolate	1.271	Cannel coal or bituminous shale, Martin's Fork.
1825	Harlan	1 284	1.70	35 70	62 60	37.40	59 60	3.00	Very light spongy .	Light-buff	750	J. C. Howard's bank, Clover Fork, Cumberland river.
1826	Harlan	1.356	5.20	31.26	63.54	36 46	60.08	3.46	Pulverulent	Light-buff	.018	Martin's Fork, Skidmore Creek.
1829	Hopkins . . .	1.351	5.00	35.26	59.74	40.26	40 24	10. 50	Light spongy . . .	Brownish-grey	3.015	Coal D, Diamond coal mines.
1830	Hopkins . . .	1.337	4.30	37.64	58.06	41.94	50.56	7.50	Light spongy . . .	Dark brownish-grey .	2 802	Coal D, St. Bernard coal mines.
1831	Hopkins . . .	1.306	3 04	36.90	60.06	39.94	49.06	11.00	Light spongy . . .	Lilac-grey	5 955	Coal B, Fleming coal mine, bottom portion.
1832	Hopkins . . .	1.290	2.70	40.74	56.56	43.44	51.64	4.92	Light spongy . . .	Light lilac-grey . . .	1.502	Coal B, Fleming coal mine, top portion.
1833	Hopkins . . .	1 323	3.28	39.32	57 10	42.60	49.54	7.86	Light spongy . . .	Lilac-grey	4.710	Coal B, Hecla coal mines, average sample.
1834	Hopkins . . .	1.326	3.82	36.38	59.80	40.20	51.50	8.70	Light spongy . . .	Lilac grey	3.639	Coal B, Hecla coal mines, lower bench.
1835	Hopkins . . .	1.326	3.20	38.30	58.50	41.50	48 50	10.00	Light spongy . . .	Lilac grey	3.345	Coal B, St. Bernard coal mines, lower drift.
1836	Hopkins . . .	1.331	2.32	37.68	60.00	40.00	51 00	9.00	Light spongy . . .	Lilac-grey	3.606	Coal D, Hecla coal mines, average sample.
1846	Jackson	1.338	2.00	41 00	57.00	43.00	43.10	13.90	Spongy	Very light buff-grey .	1.049	Cannel coal, Tom Coyle's bank, 100 feet above Congl'te.
1847	Jackson	1.321	2.00	43.00	54.34	45.66	45.58	8.76	Dense.	Grey-lavender	3.384	Cannel coal, T. J. Ballard's bank, Horse Lick.
1849	Johnson	1.291	2.00	38.20	59.80	40.20	51.00	8.80	Dense.	Light lilac-grey . . .	.956	Cannel coal, Lick Branch, White House Creek.
1850	Johnson . . .	1.294	3.10	38.60	58.30	41.70	53 50	4 80	Light spongy . .	Light brownish-grey	1.730	Rice's coal, head of Jenny's Creek.
1851	Johnson	1.280	2.60	38 00	59 50	40 70	59 30	3.00	Spongy	Light-grey	1.291	Coal from Wheeler's bank, near Paintsville.
1859	Lawrence . . .	1.317	3.26	34.22	62.52	37.48	55.36	7.16	Dense.	Light brownish-grey .	0.901	Coal 3; Peach Orchard, Miller's Branch opening.
1860	Lawrence . . .	n. d.	3.24	36.56	60 20	39.80	54.96	5.24	Dense.	Light lilac-grey . . .	1.189	Coal 3; Peach Or'd, Miller's Br'h opening (weathered).
1861	Lawrence . . .	1.245	1.84	48 10	50.06	50.00	44.74	5 76	Dense.	Buff	1.076	Cannel coal, Little Laurel Creek.
1865	Lee	1.331	2.30	38 10	59.60	4 1 40	5 .04	7.96	Light spongy . . .	Lilac-grey	2.356	From Dan'l Scott's bank, near Proctor.
1866	Lee	1.334	2.10	38.10	59.80	40.20	51.54	8.26	Spongy	Lilac-grey	3.991	Same locality as above, another entry.
1867	Lee	1.307	4.00	35 50	60.50	39.50	55.50	5.00	Light spongy . . .	Light lilac-grey . . .	1.041	Pryse's coal, Lower Stufflebean Creek.
1868	Lee	1.307	3.10	36.04	60.26	39.74	56 96	3.30	Dense spongy . . .	Light buff-grey. . . .	1.030	From Phillip's bank, Mirey Creek.
1869	Lee	1.330	3.40	32.70	63.90	36.10	57.60	6.30	Spongy	Light lilac grey . . .	1.368	From R. B. Jameson's bank, Mike's Branch.
1877	Madison . . .	1.281	2.66	33.08	63.66	36.34	56.10	7.50	Dense spongy . . .	Nearly white.	.824	Cox's coal bank, top of Big Hill.
1878	Madison . . .	1.282	1.90	45.76	52 34	47.66	44.86	7.48	Dense.	Nearly white	2.888	Moran's mine, top of Big Hill.
1878a	Magoffin . . .	1.275	1 80	45.60	52 60	47.40	43.40	9 20	Dense spongy . . .	Buff-grey	.688	Salyersville coal (half cannel), lower portion.
1879	Magoffin . . .	1.292	2.70	38 04	59.26	40.74	51.62	7.04	Light spongy . . .	Very light br'nish-grey	1.470	Salyersville coal (half cannel), upper portion.
1880	Magoffin . . .	1.309	4.34	37.36	58.30	41.70	53.14	5.16	Spongy	Light purplish-grey .	1.357	Amos Davis' coal, on Licking river.
1881	Magoffin . . .	1.270	3.70	36.64	59 66	40. 34	54.68	4.98	Light spongy . . .	Light buff-grey . . .	.944	Sacye Bank coal, near Mouth of Johnson's Creek.
1882	Magoffin . . .	1.235	2.30	51.90	45.80	54.20	37.56	8.24	Very dense	Brownish-grey . . .	1.415	Colvin's cannel coal.
1883	Martin	1.351	2.16	33.60	64.24	35.76	55 06	9.18	Light spongy . . .	Brownish-grey	2.563	Coal 1; Mouth of Collins' Creek; Warfield.
1884	Martin	1.358	2.50	33.70	63.80	36.20	52.62	11.18	Light spongy . . .	Light lilac-grey . . .	.754	Coal; Warfield; Tug Fork.
1885	Martin	1.358	2.24	33.06	64.70	35.30	52.70	12.00	Dense.	Very light lilac-grey .	.604	Warfield splint coal, above main coal.
1886	Martin	1.367	3.50	31.94	64.56	35.44	52.06	12.50	Dense.	Very light lilac-grey .	.873	Eight-feet coal, head of Laurel Fork of Nat's Creek.
1887	Martin	1.302	2.00	35.12	62.88	37.12	54.82	8.06	Dense.	Lilac-grey	.983	Coal 1; Warfield.
1888	McLean. . . .	not est	1.60	36.40	62.00	38.00	31.36	30.64	Friable	Brownish lilac-grey .	not est	Bituminous shale, near Wrightsburg.
1889	McLean. . . .	1.241	3.30	36.00	60.70	39.30	57.88	2.82	Light spongy . . .	Buff-grey	1.024	Coal, near Wrightsburg.
1890	Morgan	1.230	2.06	49.64	48.30	51.70	43.20	5.10	Spongy	Light buff-grey. . . .	.955	Pierat's cannel coal.
1891	Morgan	1.331	2.30	41.60	56.10	43.90	44.70	11.46	Very dense spongy.	Grey-buff	1.271	Cannel coal; Maynhier's bank, Elk Fork, Licking river.

TABLE II. COALS, AIR-DRIED—(Continued).

Number in Report.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Fixed carbon in the coke.	Ash.	Character of the coke.	Color of the ash.	Per centage of sulphur.	Remarks
1892	Morgan	1.353	4.26	35.24	35.24	39.50	50.10	10.40	Dense spongy	Nearly white	1.011	Six-foot coal, near West Liberty.
1896a	Menifee	1.300	5.00	39.06	55.94	44.06	53.18	2.76	Spongy	Brownish lilac-grey	1.199	Price and Fitch's bank, top of the mountain.
1896b	Menifee	1.300	5.00	32.40	62.60	37.40	58.40	4.20	Dense	Light yellowish-grey	.614	Adams' bank, Old Slate Branch, near Frenchburg.
1896c	Menifee	1.318	2.70	38.22	59.08	40.92	54.80	4.26	Spongy	Lilac-grey	1.615	Old State Road Branch.
1898	Muhlenburg	1.280	4.60	42.60	52.80	42.70	50.06	2.74	Spongy	Light-grey	1.601	Coal B, Louisville and Stroud City mines (top of bed).
1899	Muhlenburg	1.309	3.36	37.90	58.74	41.26	52.74	6.00	Light spongy	Light lilac-grey	2.686	Coal B, Memphis Coal Company's mine.
1900	Muhlenburg	1.313	5.40	35.90	58.70	41.30	53.60	5.10	Light spongy	Light lilac-grey	2.219	Coal B, Louisville and Stroud City mine.
1901	Muhlenburg	1.235	5.40	34.20	60.40	39.60	54.20	6.20	Light spongy	Bright lilac-grey	3.136	Coal B, St. Louis mines, Owensboro Junction.
1902	Muhlenburg	1.307	4.60	37.60	57.80	42.20	52.64	5.16	Light spongy	Dark brownish-grey	2.372	Coal B, St. Louis mines. "Gas coal."
1903	Muhlenburg	1.332	3.80	36.20	60.00	40.00	51.80	8.20	Light spongy	Lilac-grey	3.194	Coal B, Rothrock's mine (upper bench).
1904	Ohio	1.318	3.80	36.66	59.54	40.46	52.00	7.54	Spongy	Light lilac-grey	1.944	Coal D, McHenry coal mine (without sulphur band).
1905	Ohio	1.331	2.70	35.24	62.06	37.94	53 62	8.44	Light spongy	Lilac-grey	3.785	Coal D, McHenry coal mine (with sulphur band).
1906	Ohio	1.310	4.40	38.20	57.40	42.60	49.94	7.46	Light spongy	Light lilac-grey	2.246	Coal D, Render mine. From nut coal pile.
1907	Ohio	1.336	4.10	34.36	61.54	38.46	51.24	10.30	Light spongy	Lilac-grey	3.263	Coal D, Render mine. From the slack pile.
1908	Ohio	1.295	5.00	36.74	58.26	41 74	55.66	2.60	Light spongy	Light-brown	1.605	From Ch. W. Stephens' bank, Rough Creek.
1909	Ohio	1.297	5.90	33.80	60.30	39.70	56.90	3.40	Light spongy	Buff	1.038	From G. B. Hocker's bank, Rough Creek.
1910	Ohio	1.251	5.54	35.66	58.80	41.20	56.20	2.60	Light spongy	Light-buff	.983	From same locality as last.
1911	Ohio	1.382	5.10	30.70	64.20	35.80	54.24	9.96	Spongy	Light br'ish lilac-grey	2.164	From Marion Sandifer's bank, Big Muddy Creek.
1912	Ohio	1.386	4.80	33.70	61.50	38.50	52.26	9.24	Spongy	Brownish lilac-grey	3.364	From L. M. Patterson's mine, Point Pleasant.
1913	Ohio	1.345	3.50	36.30	60.20	39.8.	50.92	9.28	Light spongy	Brownish lilac-grey	3.524	Coal D, Williams' coal bank, Ben's Lick.
1914	Ohio	1.593	2.20	27.80	70.00	30.00	35.28	34.72	Pulverulent	Dark br'ish lilac-grey	5.694	Cannel coal or bituminous shale; H. D. Bennett's.
1915	Ohio	1.273	5.30	45.70	49.00	51.00	45 00	4.00	Dense spongy	Lilac-grey	2.150	Coal; Berry & Walker's land, Muddy Creek.
1916	Ohio	1.305	6.54	37.92	55.54	44.46	51.54	4.00	Light spongy	Light yellowish-brown	1.917	Coal; Ben. Hines' coal bank (above the clay parting).
1917	Ohio	1.295	4.80	41.00	54.20	45.80	49.14	5.06	Light spongy	Dark lilac-grey	2.356	Coal; Ben. Hines' coal bank (below the clay parting).
1918	Ohio	1.384	4.80	35.80	59.40	40.60	45.20	14.20	Spongy	Light lilac-grey	3.015	Coal E, on Rough Creek, Mouth of Brush Creek.
1919	Ohio	1.340	6.80	32.40	60.80	39.20	52.50	8.30	Spongy	Very light lilac-grey	2.109	L. D. Taylor's coal.
1920	Ohio	1.356	4.80	35.60	59.60	40.40	49.66	9.94	Spongy	Light lilac-grey	3.180	Coal D, Brown's coal bank.
1921	Ohio	1.357	6.66	33.64	59.70	40 30	51.56	8.14	Light spongy	Lilac-grey	2.768	Wm. Warden's coal, near Centretown.
1922	Ohio	1.380	6.00	34.30	59.70	40.30	50.36	9.34	Spongy	Grey-brown	4.307	From Berry & Walker's land, Hines' tract.
1923	Ohio	1.413	2.70	39.30	58.00	40.20	45.90	12.10	Spongy	Grey purplish-brown	7.959	From A. Woodward's bank, on Barrett's Creek.
1924	Ohio	1.310	6.10	37.50	56.40	43.60	50.46	5.94	Spongy	Light-grey	3.002	From Gaines' bank, near Fordsville.
1925	Ohio	1.310	5.54	35.66	58.80	41.20	48.88	9.92	Much inflated	Dark lilac-grey	4.199	From H. Dooring's mine.
1926	Ohio	1.282	3.96	40.50	55.54	44.46	52.38	3.16	Much inflated	Lilac-grey	1.407	From Henry Thompson's bank (a lower coal).
1927	Ohio	1.348	3.94	37.86	58.20	41.80	50.48	7.72	Light spongy	Lilac-grey	3.128	From Norton's coal bank.
1928	Ohio	1.321	3.70	36.64	59.66	40.34	55.30	4.36	Dense	Light purplish-brown	1.241	From Martin's bank, near Eden Lick.
1929	Ohio	1.401	3.20	37.06	59.74	40.26	47.24	12.50	Dense	Dark lilac-grey	6.809	From Henry Davis' mine (upper portion).
1936	Owsley	1.294	2.10	35.24	62.66	37.34	58.60	4.00	Spongy	Light lilac-grey	1.424	From Steffee & Samuel's mine, South Fork of Ky. river.
1937	Owsley	1.161	.50	59.70	39.80	60.20	32.34	7.46	Dense	Light-brown	not est	Cannel coal; Steffee & Samuel's mine, S. Fk. Ky. river.
1938	Perry	1.289	2.10	36.20	61.70	38.30	58.20	3.50	Light spongy	Buff-grey	.836	Coal from Josiah Cobb's bank, near Hazard (upper part).
1939	Perry	1.370	3.70	30.64	65.66	34.34	57.02	8.64	Pulverulent	Grey-buff	.654	Coal from Campbell's bank, Mace's Creek.
1940	Perry	1.303	2.06	36.74	61.20	38.80	56.30	4.90	Spongy	Brownish-grey	1.436	Coal from R. C. Comb's bank, below Hazard.

1941	Perry	1.288	1.60	36.10	62.30	37.70	56.40	5.90	Light spongy	Light-grey	.836	Coal from Logan's drift, Brashear's salt-works.
1942	Perry	1.274	1.80	40.90	57.30	42.70	53.70	3.60	Light spongy	Brown-grey	1.339	Coal from David Grigsby's bank, Lot's Creek.
1943	Perry	1.290	1.20	40.86	57.94	42.06	48.44	9.50	Dense	Light-grey	.634	Coal from D. Grigsby's bank, lower part. Cannel coal.
1944	Pulaski	1.357	2.40	36.76	60 84	39.16	50.24	10.60	Spongy	Brownish lilac-grey	2.494	Coal from Cumberland coal banks (Sub-congl'rate coal).
1945	Pulaski	1.357	2.00	35.30	62.70	37.30	52.94	9.76	Light spongy	Dark lilac-grey	3.565	Coal from Doolin's bank (a Sub-conglomerate coal).
1947	Rockcastle	1.318	2.00	36.66	61.34	38.66	51.94	9.40	Light spongy	Dark lilac-grey	2.205	Coal from Myzner & Myers' bank, Livingston (Entry 1).
1948	Rockcastle	1.357	2.20	36.50	61.30	38.70	51.70	9.60	Light spongy	Dark lilac-grey	4.802	Coal from Myzner & Myers' bank, Livingston (Entry 2).
1949	Rockcastle	1.347	2.20	35.86	61.94	38.06	54.94	7.00	Spongy	Light-chocolate	4.302	Coal from Grisham's coal mine (the brashy coal).
1950	Rockcastle	1.374	2.10	39.50	58.40	41.60	49.86	8.54	Spongy	Purplish-grey	2.933	Coal from Grisham's coal mine (lower nine inches).
1960	Whitley	n. d.	2.84	27.10	70.00	30.00	43.40	26.60	Dense	Purplish-grey	2.562	Cannel coal or bituminous shale; Cumberland Falls.
1963	Wolfe	1.336	3.74	35.52	60.74	39.26	52.64	8.10	Spongy	Lilac-grey	2.466	Coal from C. M. Hanks' bank, Compton.
1964	Wolfe	1.434	1.30	41.40	57.30	42.70	28.20	29.10	Pulverulent	Nearly white	.846	Cannel coal or bituminous shale; J. F. Ely's, Gilmore Cr.
1963	Wolfe	1.383	1.16	44.58	54.26	45.74	32.70	21.50	Pulverulent	Light lilac-grey	.530	Cannel coal? J. W. Faukner's, Stillwater Creek.
1966	Wolfe	1.294	3.50	35.20	61.30	38.70	56.70	4.60	Spongy	Lilac-grey	1.189	Coal from Hobb's bank, near Compton.

TABLE III. IRON ORES (LIMONITES), DRIED AT 212° F.

Number in Report.	County.	Iron peroxide.	Iron carbonate.	Manganese br'n oxide.	Alumina.	Lime carbonate.	Magnesia.	Phos'oric acid.	Sulphuric acid.	Comb'ed water.	Silica and silicates.	Moisture & loss.	Per centage of iron.	Per centage of phosphorus.	Per centage of sulphur.	Per centage of silica.	Remarks.
1652	Bath	70.060	. . .	not est	4 540	0.040	0 081	1.680	0.031	12.300	11.530	. . .	49.042	0.707	0.012	11.530	Slate Furnace ore, "Howard's Hill."
1653	Bath	69.728	. . .	not est	8.642	.170	.045	1.154	.134	12.650	7.930	. . .	48.809	.504	.053	7.760	Slate Furnace ore (upper part of bed).
1654	Bath	47.321	. . .	not est	5.418	.690	.079	.161	.376	12.050	33 330	.575	33.125	.070	.150	27.600	Chalybeate Springs, Pilot Knob.
1655	Bath	39.068	11.479	not est	8.346	18.710	6.159	.868	.185	7.835	7.350	. . .	30.734	.379	.074	7.560	Near Owingsville (18 to 20 feet thick).
1656	Bath	59.621	. . .	not est	12.370	.500	.144	.709	trace.	10.400	15.830	.426	41 735	.309	trace.	13.960	Old coaling bank, Clear Creek.
1657	Bath	60.329	. . .	not est	12.532	trace.	.173	.709	trace.	9.580	9.720	.957	46.440	.309	trace.	9.060	Richardson's bank, Clear Creek.
1658	Bath	65.310	. . .	not est	11.947	.730	.140	.825	trace.	11.000	9.580	.468	44.570	.360	trace.	9.580	Pergam bank, Clear Creek.
1762	Edmonson	40.798	. .	1.293		trace	trace.	1.019	.360	7.250	50.030	. . .	28.559	.445	.207	46.760	Still-house Branch of Bear Creek.
1763	Edmonson	47.724	. . .	2.501		trace	trace.	.697	.315	8.250	41.145	. . .	33.407	.304	.125	39.560	Dismal Creek.
1764	Edmonson	49.906	. . .	3.330		trace.	trace.	.694	.395	9.320	36.780	. . .	39.407	.303	.158	33.460	Sycamore Branch of Bear Creek.
1765	Edmonson	32.820	. . .	2.356		trace.	trace.	.984	.285	8.330	55.180	.045	22.974	.430	.114	48.960	Mill Branch of Bear Creek.
1766	Edmonson	77.871	. . .	not est	1.444	trace.	.070	.505	trace	11.050	8.660	.040	54.510	.221	trace.	8.660	Cave Branch of Gulf Creek.
1770	Estill	74.127	. . .	not est	3.542	.390	.461	.601	not est	11.270	9.580	.029	51.889	.262	not est	7.860	From Lustre drift.
1771	Estill	65.535	. . .	not est	2.798	.450	1.073	.537	not est	9.800	20.480	. . .	45.874	.234	not est	18.260	Logan Ridge limestone ore.
1772	Estill	75.598	. . .	not est	1.971	.540	.258	.601	not est	11.730	8.910	.392	52.918	.262	not est	7.260	Tubbs' bank ore.
1773	Estill	65.591	. . .	not est	5.762	trace.	.248	.447	trace.	11.000	16.230	.722	45.914	.195	not est	14.160	Horse Ridge ore banks.
1794	Grayson	48.913	5.735	not est	7.125	9.410	.144	.489	.199	8.905	19.080	. . .	36.526	.209	.080	16.760	Old Nolin Furnace ore.
1862	Lawrence	67.545	. . .	not est	1.280	trace.	trace.	.135	.423	10.150	20.480	.017	47.250	.059	.175	16.960	Limestone ore, Upper Blane Creek.
1863	Lawrence	55.693	. . .	not est	1.151	trace.	trace.	.284	.302	10.510	31.280	.780	39.105	.124	.111	25.660	Red kidney ore, Cherokee Creek.
1897	Menifee	54.750	. . .	not est	14.515	trace.	.047	.697	trace.	8.600	20.830	.559	38.750	.304	trace.	19.500	From Branch of Beaver Creek.
1930	Ohio	61.179	. . .	not est	15.503	trace.	.176	.648	not est	9.273	13.830	. . .	48.825	.283	not est	9.960	Alfred Ashby's, Walton Creek.
1931	Ohio	44.594	. . .	not est	20.419	trace.	.248	.287	not est	8.860	26.550	. . .	31.216	.125	not est	23.420	Dooring's iron bank.
1932	Ohio	44.916	. . .	not est	13.204	trace.	.176	.280	not est	8.920	32.504	. . .	31.241	.177	not est	24.460	Same locality.
1933	Ohio	15.044	. . .	not est	6.113	trace.	.338	.073	not est	6.158	72.280	. . .	10.531	.032	not est	69.100	Ochreous limonite.

TABLE III (A). IRON ORES (CLINTON OR DYESTONE ORES), DRIED AT 212° F.

Number in Report.	State.	Iron peroxide.	Iron carbonate.	Manganese brown oxide.	Alumina.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Combined water.	Silica and silicates.	Moisture and loss.	Per centage of iron.	Per centage of phosphorus.	Per centage of sulphur.	Per centage of silica.	Remarks.
A	Tennessee . . .	77.380	. . .	3.941		0.420	trace	0.319	trace.	2.500	15.960	not est	54.166	0.140	trace.	15.760	Cumberland Gap; Poor Valley Ridge, upper bed.
B	Tennessee . . .	73.935	. . .	5.776		4.510	.266	.319	trace.	3.850	11.730	not est	51.754	.140	trace.	11.730	Cumberland Gap; Poor Valley Ridge, upper bed.
C	Tennessee . . .	47.963	. . .	2.130		1.230	.194	.575	trace.	4.000	43.690	not est	33.575	.251	trace.	42.760	Cumberland Gap; Poor Valley Ridge, middle bed.
D	Tennessee . . .	80.820	. . .	not est		not est	not est	not est	not est	not est	not est	not est	56.574	not est	trace.	11.260	Cumberland Gap; from Old Clinton Furnace.
E	Pennsylvania .	38.48	*4.37	not est	9.56	†1.06	trace	1.48	.05	4.500	37.99	not est	30.34	.210	.05	37.99	Dysart's mine, middle bed.

* Iron protoxide. † Lime.

TABLE IV. IRON ORES (CLAY IRON-STONES), DRIED AT 212° F.

Number in Report.	County.	Specific gravity.	Iron carbonate.	Iron peroxide.	Alumina.	Lime carbonate.	Magnesia carbonate.	Manganese carbonate.	Phosphoric acid.	Sulphuric acid.	Silica and silicates.	Water and loss.	Per cent. of iron.	Per cent. of phosphorus.	Per cent. of sulphur.	Per cent. of silica.	Remarks.
*1769	Estill	not est	76.491	4.049	2.014	5.400	0.514	not est	0.409	0.267	9.330	. . .	39.758	0.178	0 107	7.660	Tubbs' bank, near Estill Furnace.
1858	Lawrence . . .	1.351	. . .	. . .	not est	. . .	. . .	. . .	. . .	. . .	. . .	. . .	33.264	not est	.483	7.460	From near Louisa. Black Band ore.
1858a	Lawrence . . .	not est	. . .	. . .	not est	. . .	. . .	. . .	. . .	. . .	. . .	. . .	33.923	not est	.354	not est	From near Louisa. Black Band ore.
1858b	Lawrence . . .	not est	. . .	. . .	17.92	*.924	†.150	. . .	. . .	. .	. . .	. . .	25.746	.553	. . .	6.36	Louisa Fork Big Sandy river. Black Band ore.‡

* Per cent. of lime. † Per cent. of magnesia. ‡ Per cent. of bituminous matters, 13.700: these not estimated in 1858 and 1858a.

TABLE V. PIG IRONS.

Number in Report.	County.	Specific gravity.	Iron.	Graphite.	Combined carbon.	Manganese.	Silicon.	Slag.	Aluminum.	Calcium.	Phosphorus.	Sulphur.	Total carbon.	Remarks.
1659	Bath	7.007	92.631	3 840	0.710	not det.	1.520	0.100	not det.	0.090	0.363	0.278	4.550	Cold blast No. 1 charcoal; Bath Furnace.
1660	Bath	7.067	92.056	3.640	.310	not det.	1.760	.100	not det.	.116	1.080	.218	3.950	Old Slate Furnace.
1661	Bath	7.142	93.106	3.860	.590	not det.	.914	.160	not det.	not det.	.527	.011	4.45	Cold blast No. 1 charcoal car wheel; Cot. Fur.
1662	Bath	7.017	91.924	3.440	1.060	not det.	1.319	.260	not det.	not det.	.220	.107	4.50	Cold blast No. 2 charcoal; Bath Furnace.
1663	Bath	7.092	93.472	3.100	1.510	not det.	.652	.160	not det.	not det.	.290	.121	4.610	Cold blast No. 3 charcoal; Bath Furnace.
1664	Bath	7.168	93.004	2.700	1.410	not det.	1.007	.260	not det.	not det.	.120	.172	4.110	Cold blast No. 4 charcoal; Bath Furnace.
1700	Boyd	6.921	92.962	2.100	1.310	not det.	2 525	.220	not det.	not det.	.568	.114	3.410	Hot blast mill iron; Bellefonte Furnace
1701	Boyd	6.163	89.912	2.900	.070	not det.	5.082	.280	not det	not det.	.417	.114	2.970	Hot blast silver-grey; Bellefonte Furnace.
1716	Carter	6.930	93.268	3.950	.770	not det.	1.799	.160	not det.	not det.	.680	.081	4.720	Hot blast mill iron; Mt Savage Furnace.
1717	Carter	7.042	91.584	2.600	1.070	not det.	3.058	.620	not det.	not det.	.609	.152	3.670	Hot blast foundry No. 2; Mt. Savage Furnace.
1718	Carter	7.435	89.687	2.300	.500	not det.	5.575	.660	not det.	not det	.609	.136	2.800	Hot blast silver-grey; Mt. Savage Furnace.
1774	Estill	7 108	93.728	3.520	.780	.389	1.202	.360	.264	not det.	.290	.080	4.300	Cold blast No. 3 charcoal; Red River Furnace.
1775	Estill	not est.	93.963	2.000	2.550	.181	.363	.320	.648	not det.	.338	104	4.550	Cold blast No. 5 charcoal; Red River Furnace.
1776	Estill	7.226	94.174	3.340	1.110	not det.	.447	.360	not det.	not det.	.402	.182	4.450	Cold blast No. 1 charcoal car wh'l iron; R. R. F.
1777	Estill	7.272	92.582	3.500	1.200	not det.	.960	.360	not det.	not det.	.444	.066	4.700	Cold blast No. 1 charcoal car wh'l iron; Estill F.
1801	Greenup	not det.	92.284	2.960	.690	not det.	3.011	.880	not det.	not det.	.474	not est	3.050	No. 1 foundry iron; Hunnewell Furnace.
1802	Greenup	not det	90.630	2.500	.830	not det.	4.969	.360	not det.	not det.	.741	.040	3.330	No. 1 hot blast silver-grey; Pennsylvania Fur.
1803	Greenup . . .	not det.	92.060	2.700	.030	not det.	3.104	.300	not det.	not det.	.710	.033	3.330	No. 1 foundry iron; Pennsylvania Furnace.
1804	Greenup	not det.	94.704	2.900	.780	not det.	1.193	.200	not det.	not det.	.860	.033	3.680	Mill iron; Pennsylvania Furnace.
1805	Greenup	not det.	92.856	3.230	. . . .	not det.	2.545	.360	not det.	not det.	.817	.046	3.230	No. 2 foundry iron; Pennsylvania Furnace.
1806	Greenup	6.680	92 697	2.100	1.000	not det.	1.813	not est.	not det.	not det.	.454	.218	3.100	No. 2 cold blast iron, from blue ore; Laurel F.
1807	Greenup	6.927	91 596	2.900	.250	not det.	3.417	.800	not det.	not det.	.247	.237	3.150	Hot blast mill iron, stone coal; Raccoon Fur.
F	Tennessee . . .	not est.	92.828	3.260	.840	.153	1.668	.480	.766	.112	.145	.068	4.100	From Clinton ore; Old Clinton Furnace.

TABLE VI. CLAYS, DRIED AT 212° F.

Number in Report.	County.	Silica and silicates.	Silica.	Alumina.	Iron oxide.	Lime.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Water expelled at red heat.	Remarks.
1697	Boone		48.360	33.060		3.057	0.367	not est.	not est.	4.664	1.706	8.786	Clay from near Burlington.
1767	Edmonson		80.160	11.600		.760*	.560	not est.	not est.	3.854	.583	2.483	Clay from Sowder's farm.
1768a	Edmonson		77 160	16.800		.480*	not est.	not est.	not est.	1 002	.484	4.340	Clay from Sowder's farm (the upper part).
1768b	Edmonson		74.460	20.440		.640*	not est.	not est.	not est.	not est.	not est.	4.460	Clay from Sowder's farm (the second part).
1768c	Edmonson		71.560	22.800		.680*	not est.	not est.	not est.	not est.	not est.	4.900	Clay from Sowder's farm (the third part).
1768d	Edmonson		67.560	22.540		.980*	.671	.025	. . . .	2.470	.058	5.690	Clay from Sowder's farm (the lowest part).
1873	Lincoln		61.580	23.946	5.814	.201	.850	not est.	not est.	1.542	.362	5.705	Clay from head waters of Green river.
1870a	Madison		59.976	27.640		.280*	.606	not est.	not est	3.931	.547	7.020	Potter's clay (Upper Silurian); Waco.
1876b	Madison		56 960	28.740		.200*	.752	not est.	not est.	2.501	.315	10.531	Potter's clay (Upper Silurian); Waco.

* Carbonate.

TABLE VII. MARLY SHALES; MARLS AND SILICIOUS CONCRETIONS, DRIED AT 212° F.

Number in Report.	County.	Silica and silicates.	Silica.	Alumina.	Iron oxide.	Lime carbonate.	Lime.	Magnesia carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Total potash.	Total soda.	Water, &c.	Remarks.
1665	Barren	8.860	. . . .	5.800		66.160	. . .	14.083	. . .	not est	not est	. . .	5.097	. . .	From Proctor's Cave
1741	Clinton	. . . .	70.800	18.840		. . . .	0.594	. . . .	4.358	not est	not est	4.240	.794	. . .	From Cumberland City Mines.
1788	Grayson	74.360	. . . .	14.451		1.60	. . .	. . . .	1.715	1.089	not est	4.240	.948	7.000	Nodular ferruginous clay, Bear Creek.
1789	Grayson	68.380	. . . .	12.451	7.588	1.380	. . .	. . . .	1.643	not est	not est	5 049	1.060	8.250	Nodular ferruginous, Canolaway Creek.
1790	Grayson	44.760	. . . .	26.221		9.160	. . .	6.629		1.089	not est	4.944	1.061	6.136	Marly shale below limestone; Hot Branch, Bear Creek.
1791	Grayson	59.920	. . . .	27.811		.880	. . .	. . . .	.824	.109	not est	5.554	.657	4.245	Marly shale, Haycraft's Lick.
1792	Grayson	58.961	. . . .	25.758		1.580	. . .	. . . .	4.437	.102	not est	5.145	.347	3.671	Red marly shale, Haycraft's Lick.
1793	Grayson	60.760	. . . .	23.071		1.180	. . .	. . . .	.497	.089	not est	4.093	.438	9.872	brown marly shale, Cedar Knob Lick.
1864	Lawrence	80.660	. . .	1.800		.260	. . .	. . . .	. . .	not est	not est	not est	not est	3.88	Carbonaceous matters 13.40. Petrifaction.

APPENDIX.

THE CLINTON IRON ORE. DYESTONE ORE OF TENNESSEE. FOSSIL ORE.

In consequence of the great abundance of this valuable ore in the mountainous region of Tennessee, very near to the Kentucky line, and in view of the proximity of Kentucky coal beds to these ore beds, the members of the Geological Survey collected some characteristic average samples from them, which have been analyzed, with the following results:

A. "*Clinton Ore; upper bed, in Poor Valley Ridge. Cumberland Gap, Tennessee. Average sample from a number of exposures of the beds. By P. N. Moore. Clinton Group.*"

A soft ore, easily breaking into irregular laminæ or scales; filled with small disc-formed concretions or fossil casts. Powder of a blood-red color.

B. "*Clinton Ore; upper bed. Foot of Poor Valley Ridge, on a branch down from the Virginia Road. Cumberland Gap, Tennessee. Collected by P. N. Moore.*"

Very much like the preceding.

C. *Clinton Ore. Middle bed of the ore; twenty-six inches thick. Cumberland Gap, &c. Collected by P. N. Moore.*"

Harder and more compact than the preceding; containing but few fossil-like concretions or casts. Externally of a brownish-ochreous appearance. Powder of a light reddish-brown color.

D. "*Dyestone Ore, from near Cumberland Gap, Tennessee. From old Clinton Furnace. Clinton Group.*"

For comparison with the above, the analysis of a similar ore from Pennsylvania, analyzed by Professor Persifer Fraser, of the University of Pennsylvania, is appended.

E. *"Hard Fossil Ore, or Clinton Ore. Middle bench of Drysart's mine. Pennsylvania."*

COMPOSITION OF THESE CLINTON ORES, DRIED AT 212° F.

	A.	B.	C.	D.	E.
Specific gravity	3.942	3.914	3.190	....	....
Iron peroxide	77.380	73.935	47.965	80.820	38.48
Iron protoxide	....	....	....	....	4.37
Alumina, Manganese oxide	3.941	5.776	2.130	....	9.56 not est.
Lime carbonate	.420	4.510	1.230	....	*1.06
Magnesia	a trace.	.266	.194	....	a trace.
Phosphoric acid	.319	.319	.575	....	1.48
Sulphuric acid	a trace.	a trace.	a trace.	....	†.05
Combined water	2.500	3.850	4.000	....	4.500 ‡2.54
Silica and insoluble silicates	15.960	11.730	43.690	....	37.99
Total	100.520	100.386	99.784	....	100.00
Per centage of iron	54.166	51.754	33.575	56.574	30.34
Per centage of phosphorus	.140	.140	.251	....	.21
Per centage of sulphur	a trace.	a trace.	a trace.	....	.05
Per centage of silica	15.760	11.730	42.760	11.260	37.99

*Lime. †Sulphur. ‡Alkalies.

Professor J. P. Lesley, Chief of the Pennsylvania Geological Survey, states that the iron produced from this ore is always "cold-short," but that it is valuable to work with richer and less fusible ores. This is the character of this ore in other localities, and it appears to have a wide range, extending even into Wisconsin. But the samples examined in this laboratory do not yield as much phosphoric acid as the usual average of this ingredient; and from experiments which have been made in smelting this Tennessee ore, it is believed that a good tough iron can be made from it.

F. *A sample of the Pig Iron made at the furnace at the Cumberland Gap, from the Clinton Ore, was obtained by Mr. P. N. Moore, and analyzed.*

The iron is fine-grained mill iron? It yields with difficulty to the file, but extends under the hammer a little more than is usual with pig iron.

COMPOSITION OF THIS CLINTON PIG IRON.

Iron	92.828	
Graphite	3.260	Total carbon = 4.100
Combined carbon	.840	
Manganese	.153	
Silicon	1.668	
Slag	.480	
Aluminum	.766	
Calcium	.112	
Magnesium	.270	
Phosphorus	.145	
Sulphur	.068	
	100.590	

It will be seen that this iron will compare favorably with the best quality of pig metal.

G. "*Coal from Winter's Gap, near Knoxville, Tennessee.*"

In a valley about ten miles from the Cincinnati Southern Railroad. The bed is said to be seven feet thick, and three acres of it have been mined out without leaving a pillar. Said to be the best pit coal in Tennessee. The sample was presented by Gen. Winder at the Centennial Exhibition. It is quite a pure-looking, firm, pitch-black, glossy coal; not breaking into thin laminæ; having no apparent fibrous coal, and very little granular pyrites.

COMPOSITION, AIR-DRIED.

Specific gravity	1.256		
Hygroscopic moisture	1.64	Total volatile matters	38.40
Volatile combustible matters	36.76		
Spongy coke	61.60	Fixed carbon in the coke	59.90
		Carrot-colored ash	1.70
	100.00		100.00

The per centage of sulphur is . 1.450

This is a coal of remarkable purity, leaving a smaller proportion of ash than any coal examined during the Geological Survey of Kentucky. Of course it cannot be considered an *average* sample of the bed, yet it is evidence of its superior quality. The proximity of this bed of coal to the Cincinnati Railroad makes it matter of interest to our citizens.

GERMAN GLASS POT FIRE-CLAY, AS COMPARED WITH SAMPLES OF KENTUCKY CLAY.

On a recent visit to the great International Centennial Exhibition at Philadelphia, the attention of the writer was attracted by an exhibit of this fire-clay, supposed to be one of the most refractory known, and imported for the construction of crucibles to withstand a very high heat, but particularly for our glass manufacturers, who seem to agree that no other known clay will so completely withstand the great heat of their furnaces, and the fluxing influence of the melted glass, as this. It is consequently almost universally used by them as the material for the construction of the glass pots or large crucibles, in which the glass is made and melted.

The exhibit of this clay at the Centennial Exhibition was made by J. Goebel & Co., importers of German clay, and manufacturers of crucibles, &c., Maiden Lane, New York. It showed the clay in its natural and prepared conditions; and accompanying the specimens was a report of the chemical analysis of the material, said to have been made in Germany, a copy of which is appended.

With a view to study this valuable clay, in comparison with some Kentucky samples from our coal measures, the writer secured a sample from what appeared to be a washed and prepared specimen on exhibition, which had been moulded into a cubical block, and which he has analyzed.

H. *The Clay is of a light grey color; adheres strongly to the tongue; and exhibits a large irregularly conchoidal fracture. Before the blow-pipe it fused only on the extremity of the small pointed fragment, into a white slag.*

I. *Another specimen of this German Glass Pot Clay was obtained at the Co-operative Window Glass Works, at the foot of Coal Hill, opposite Pittsburg (near the inclined railroad). The pot-maker, who furnished the sample from a partly used barrel of the material, stated that it was in the condition in which it was imported from Germany.*

This had not been re-worked or washed. It resembles the preceding, but is a little more friable, and slightly lighter colored. Its powder, however, is somewhat darker than the powder of that. Before the blow-pipe it acted like that.

J. *Copy of the analysis of this clay made in Germany, as exhibited by J. Goebel & Co.*

For comparison with these, I append a copy of the analysis of some clay from Carter county, Kentucky (see volume I, Kentucky Geological Reports, new series, page 179, lower paging), labeled—

"No. 1337—*Fire-clay; average sample from the upper bed, four feet thick, on both sides of the hill. Ridge between Grassy and Three Prong Creek. Boone Furnace property. Whole bed eight to ten feet thick. Collected by P. N. Moore.*"

This clay, forming a heavy stratum, is in a compact state—so hard as scarcely to be scratched with the nail; breaking into angular fragments. It is of a light-grey color, and becomes plastic when reduced to powder.

COMPOSITION OF THESE FIRE-CLAYS, DRIED AT 212° F. (Except J, which seems to have been more thoroughly dried).

	H.	I.	J.	No. 1337.
Silica	*70.860	†73.660	70.60	48.560
Alumina	20.900	19.460	23.60	37.471
Iron oxide (calculated as peroxide)	1.560	1.560	. . . . .	a trace.
Iron sulphide	. . . . .	. .	1.10	. . . . .
Lime	.347	.168	.36	.112
Magnesia	.220	.209	.45	a trace.
Phosphoric acid	not est.	not est.	not est.	.255
Sulphuric acid	not est.	not est.	not est.	not est.
Potash	.578	.520	not est.	.289
Soda	.112	.046	not est.	.283
Water expelled at red heat	6.800	6.200	‡3.89	12.030
Total	101.377	101.823	100.00	99.000

* Including about four per cent. of fine sand.
† Including about three and a half per cent of fine sand.
‡ Organic matters and loss.

The iron peroxide obtained in the analyses of H and I was doubtless derived from iron sulphide in the clay. The apparent excess is probably due mainly to fixed alkalies in the pre-

cipitated alumina, which may be estimated correspondingly too high.

The large proportion of silica in the German clay (a part of which is in the state of fine sand) is notable in comparison with the Carter county clay; and this large proportion of silica or sand increases the refractory quality of the clay. But pure fine sand or pulverized quartz could quite cheaply be added to our clay, which, in other respects, seems to be at least equal in quality as a fire-clay to the German article, containing even less of those ingredients which increase the fusibility of clay, viz: iron oxide, lime, potash, soda, and magnesia. How the phosphoric acid acts in this relation is said not to have been fully determined by experiment; but it undoubtedly increases the fusibility. As will be seen, the proportion of this ingredient was not ascertained in the German clay, although it is no doubt present in notable quantity.

There can be little doubt that some of our native fire-clays can be made quite refractory by a judicious process of preparation or purification, including, perhaps, washing with water, or water containing chlorohydric acid, which is very cheap, the addition of pulverized quartz, &c.

In this relation we may notice a beautiful hydrated silicate of alumina—the Indiana kaolin, or what is denominated *Indianaite* by Prof. E. T. Cox, of the Indiana Geological Survey—a large and handsome sample of which was exhibited at the Centennial. This remarkable clay-like mineral, which was discovered first in Illinois, and called Golconda clay, was found in Lawrence county, Indiana, in 1875, forming a six feet bed, just under the coal measures conglomerate, and over a bed of brown hematite iron ore. Where it has not been impregnated with iron oxide it is a pure hydrated silicate of alumina, of the composition of halloysite, passing in its greenish portions into alophane.

This so-called porcelain clay soon attracted the attention of potters, and is now in great demand for the manufacture of the finer qualities of pottery ware. The writer believes, however, from the brief examination he has given it, that it de-

serves a more exalted application, being, when pure and free from infiltrated iron oxide and lime, more refractory before the blow-pipe than any clay he has examined. It is therefore believed that it might find a more suitable application in the manufacture of the most refractory crucibles, and that, when mixed with pure fine sand or pulverized quartz, it might very well answer for glass pots.

The general composition of the white variety, as reported by Prof. Cox (Geological Report of Indiana, 1874, page 18), is as follows:

Silica	45.90
Alumina	40.34
Lime	trace.
Water	13.26

A specimen of this mineral, obtained by the writer from that exhibited at the Centennial (beautifully translucent; nearly white, with a slight greenish tint), when examined for fixed alkalies, gave 0.198 per cent. of *potash*, and 0.204 of *soda*, when dried at 212 F. It was not examined for alkaline earths or phosphoric acid.

This mineral, which may be made so useful in the arts, may doubtless be discovered in Kentucky in a similar geological position with that in Indiana.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

CHEMICAL REPORT

OF THE

SOILS, COALS, ORES,

IRON FURNACE PRODUCTS, CLAYS, MARLS, MINERAL WATERS, ROCKS, ETC.,

OF KENTUCKY.

BY ROBERT PETER, M. D., ETC., ETC.,
CHEMIST TO THE SURVEY.

THIRD CHEMICAL REPORT IN THE NEW SERIES, AND THE SEVENTH SINCE THE BEGINNING OF THE KENTUCKY GEOLOGICAL SURVEY.

STEREOTYPED FOR THE SURVEY BY MAJOR, JOHNSTON & BARRETT, YEOMAN PRESS, FRANKFORT, KY.

INTRODUCTORY LETTER.

CHEMICAL LABORATORY,
KENTUCKY GEOLOGICAL SURVEY,
LEXINGTON, KY., April, 1878.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: I have the honor to make herewith a report of the results of the chemical work performed for the Kentucky Geological Survey from February of last year up to the present time.

Very respectfully,

ROBERT PETER.

CHEMICAL REPORT OF THE SOILS, COALS, ORES, PIG IRONS, CLAYS, MARLS, MINERAL WATERS, ROCKS, &c., OF KENTUCKY.

Of the chemical analyses herewith reported, more than one hundred and thirty in number, seventy-four are of soils, subsoils, and under-clays; of which three, reported in the Appendix, are from Texas. These latter were examined for the purpose of comparison with our Kentucky soils.

The limits of variation, in the proportions of the essential ingredients of the seventy-one Kentucky soils, are shown in the following table, viz:

	Per ct.	Number.	County.	Per cent.	Number.	County.
Organic and volatile matters vary from . . .	9.185	in 2,037	in Hardin	to 2.045	in 1,986	in Allen
Alumina and iron and manganese oxides vary from	24.465	in 2,015	in Grant	to 3.096	in 2,029	in Grayson
Lime carbonate varies from	9.425	in 2,015	in Grant	to .030	in 1,968	in Allen
Magnesia varies from.	.824	in 2,022	in Grant	to .025	in 2,042	in Hardin
Phosphoric acid varies from.	.823	in 2,014	in Grant	to .013	in 1,968	in Allen
Potash extracted by acids varies from . . .	1.778	in 2,022	in Grant	to .035	in 2,041	in Hardin
Soda extracted by acids varies from	.617	in 2,009	in Grant	to traces	in several	
Sand and insoluble silicates vary from	59.940	in 2,015	in Grant	to 92.980	in 1,967	in Allen
Water, expelled at 380° F., varies from . . .	2.715	in 2,037	in Hardin	to .483	in 2,030	in Grayson
Water, expelled at 212° F., varies from . . .	6.575	in 2,013	in Grant	to .950	in 1,967	in Allen
Potash, in the insoluble silicates, varies from .	2.910	in 2,037	in Hardin	to .722	in 1,979	in Barren
Soda, in the insoluble silicates, varies from . .	1.214	in 2,009	in Grant	to .022	in 2,080	in Oldham

In the sample of cretaceous soil from Collins county, Texas, called "black waxy" soil, there were 17.085 per cent. of lime carbonate, 0.497 of potash extracted by acids, while the 61.840 per cent. of sand and insoluble silicates contained only 0.443 per cent. of potash in the insoluble silicates.

The specimens from Grant county, which appear to such advantage in this comparative table, are of heavy, tough under-clays, excavated from some of the cuts on the Cincinnati Southern Railroad, some of which were called by the doubtful name of "hard pan" by the contractors. From the too large proportion of clay which they contain, as well as their resulting physical constitution, they would by no means prove as productive, under culture, as might be inferred from

their chemical composition alone. The fact that favorable physical conditions are as necessary to the fertility of the soil as the chemical conditions, has long been known; but both the chemical and physical are equally indispensable.

These heavy under-clays, which are so rich in some of the mineral elements of plant nourishment, might doubtless be used with advantage, in the manner of marl, as a top-dressing on light or sandy, poor or exhausted soils. They would also answer for common pottery or bricks.

The five samples of *coals* examined, from Butler, Greenup, and Madison counties, presented the usual characteristics of our good Kentucky coals, some of them being better than the average, because of their small proportions of ash and sulphur, especially the sample from Big Hill, in Madison county.

The *limonite iron ores*, from Lyon and Trigg counties, proved to be rich, containing from 46.320 to 50.195 per cent. of iron; they are also remarkably free from sulphur, and contain less than the average of phosphorus, which latter ingredient was found in them only in the proportions of from 0.079 to 0.220 per cent. of the ore. The pig irons smelted from these ores were found also to be generally of very good quality.

Amongst the *clays* which were analyzed, that from Bald Knob Church, Ohio county—No. 2076—was found to be quite refractory, and it may very probably be made available for fire-clay if in sufficient abundance.

Seventeen different samples of *limestone* were examined, many of which were from the phosphatic layers in the blue limestone of Fayette county, mentioned in the preceding Report. In fourteen samples, mostly from the same quarry, and all from the same neighborhood, the proportions of phosphoric acid were found to vary from 1.462 per cent. in No. 2002 up to 21.940 per cent. in sample four of No. 2004. (See Fayette county.)

While these interesting phosphatic layers, in the Lower Silurian limestone of this county, have not as yet been found regular and continuous enough, perhaps, to justify working for

the manufacture of superphosphate, they are yet quite interesting, as throwing much light on the superior fertility of our Lower Silurian, or so-called "Blue-grass soil." As will be seen, the analyses of some of the most abundant of the fossils of this limestone did not develop in these any unusual proportion of phosphoric acid.

One of the limestones analyzed—No. 2073—a ferruginous limestone from Rough creek, Ohio county, was found, when calcined, to possess the properties of hydraulic cement.

The lead ore found in our limestone, usually associated with zinc sulphide in veins of baryta sulphate, examined for silver, was found to give the usual negative result. Indeed, general experience, hitherto, seems to show that very little silver is associated with the galena found in undisturbed limestone layers; that ore being most generally argentiferous which is in veins in the rocks which have been much disturbed by volcanic action.

The re-examination of the *mineral waters* of the Olympian Springs, in Bath county, and of the Lower Blue Lick Springs, in Nicholas county, has developed several interesting facts. Not only is it shown that the general composition of these celebrated waters has not been altered, or the waters weakened sensibly, during the considerable period intervening between the analyses, but also several new ingredients, in small quantities, have been discovered in them. Not the least interesting of these are boracic acid and lithium compounds. Compounds of barium and strotium found in these, also in minute proportions, are believed to be, like the above substances, more generally prevalent than was formerly supposed.

Several other mineral waters, deserving of a more complete examination, were qualitatively examined. Kentucky is quite rich in these waters, and a more systematic study of them than has, as yet, been possible, is desirable.

The chemical analyses of the *ashes* of the *Hungarian grass*, *German millet*, &c., together with the microscopic photographs of parts of their silicious skeletons by Mr. Alex. T. Parker and Mr. J. Mullen, and the experiments to discover the nature of

the peculiar "root action" of these plants in their decomposition of the silicates of the soil, as well as to determine the nature of the special acid solvents exuded from the plants for this purpose, detailed in the Appendix, throw some light on the mysterious selective power of vegetables, by which materials, very different in kind and quantity, are appropriated by different plants from a soil common to all. Some, because probably of superior decomposing power which they exert over the silicates of the soil, being able to extract essential mineral ingredients and thrive, where others die of inanition, for want of the proper solvent or digestive agent.

To produce the silicious cell-casts and skeleton of the Hungarian grass and German millet, the silicious material must have been dissolved in water, in unusually large proportion, in the vicinity of the roots of these plants. Unless in solution, it could not penetrate the cell walls.

It is well known to chemists that when silicates are decomposed, by acids or other agents, in the presence of water, that the siliqic acid thus produced is soluble to a large amount in that fluid; but that it may again be easily brought to an insoluble condition, as it exists in flint or sand, by the subsequent separation of the water; and this fact, with the demonstration of the exudation from the rootlets of these plants of an acid fluid containing oxalic, phosphoric, and other acids, probably in greater quantity than is produced by many other vegetables, enables us to guess how these may decompose more of the silicates of the soil than other plants and absorb more dissolved silicic acid.

Plants, like animals, vary greatly in their natural power of appropriating essential elements of food. Some live and thrive on food of most difficult digestion; others, like the young of most animals, require nourishment in the most soluble and available condition. Some, like the Hungarian grass and other plants which grow on sterile soils, can extract their essential mineral food from the hardest stony particles; others, like our ordinary grain-producing plants, depend more on the natural soil solution, which brings their food to their roots.

already in a condition to be most readily absorbed. Peculiar root action on the soil is no doubt common, in a greater or less degree, to all plants; yet, that the common soil solution, produced by the solvent action of the atmospheric waters upon the soil ingredients, is also a common source of plant food, is equally demonstrable.

ALLEN COUNTY.

No. 1967—SOIL, *labeled "Virgin soil, from the surface of the tract of land of about fifty square miles in extent, in the eastern part of Allen county, called the 'Buncombe tract.' A very poor district. Forest growth: scrub oak, black oak, poplar, chestnut, hickory, &c. Produces about three to five barrels of corn to the acre (equal to fifteen to twenty-five bushels). Sub-stratum arenaceous, clayey, and calcareo-silicious rocks; decayed to the depth of fifteen feet." Collected by Rev. Herman Hertzer.*

The dried soil is of a light dirty-buff color. The coarse sieve removed from it only a few small ferruginous concretions. The silicious residue, after digestion in acids, all passed through fine bolting-cloth, except a small proportion of small rounded grains of quartz and undecomposed silicates, and a few very small silicified entrochi.

No. 1968—"SUBSOIL *of the next preceding soil," &c., &c. Collected by Rev. Herman Hertzer.*

Of a lighter and more yellowish buff color than the preceding; containing fewer small ferruginous concretions. The fine bolting-cloth separated from the silicious residue only a few small rounded grains of quartz and of undecomposed silicates of various tints.

No. 1969—"SURFACE SOIL, *one year in cultivation. Upland. Land of William H. H. Mitchell, one mile west of Scottsville, Allen county. Forest growth: a maple grove. Product: fifty to sixty bushels of corn to the acre." Collected by Rev. Herman Hertzer.*

The dried soil is of a light greyish-umber color. The coarse

sieve removed from it a few angular fragments of ferruginous quartzose rock. The fine bolting-cloth separated from silicious residue a small quantity of fine rounded particles of quartz and undecomposed silicates of a reddish-grey color.

No. 1970—"SUBSOIL *of the next preceding*," *&c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is very much in color like the surface soil, being only slightly lighter. The coarse sieve and bolting-cloth removed similar fragments and particles from the soil and the silicious residue. The rounded particles of undecomposed silicates and quartz amounted to about four and a half per cent. of the subsoil.

No. 1971—"SURFACE SOIL. *Upland, from the farm of Wm. H. H. Mitchell (same locality as the preceding), which has been in cultivation for sixty years. Yields twenty-five bushels of corn per acre; eight to ten bushels of wheat; or fifteen to twenty of oats. Original forest growth: chestnut, maple, oaks, poplar, &c. Geological formation: the Keokuk Group—calcareo-silicious and argillaceous rocks and shales; decayed to the depth of twenty feet below the soil.*" *Collected by Rev. Herman Hertzer.*

The dried soil is of a buff color. The coarse sieve separated from it some small quartzose concretions, silicified entrochi, and iron gravel. The silicious residue, from the digestion in acid, all passed the fine bolting-cloth except a few rounded grains of milky quartz and of dark-colored undecomposed silicates, with some minute silicified entrochi.

No. 1972—"SUBSOIL *of the next preceding*," *&c. Collected by Rev. Herman Hertzer.*

The subsoil is lighter and brighter colored than the surface soil. The coarse sieve removed from it fewer quartzose and ferruginous concretions than from that, and the bolting-cloth separated fewer silicious particles.

COMPOSITION OF THESE ALLEN COUNTY SOILS, DRIED AT 212° F.

	No. 1967.	No. 1968.	No. 1969.	No. 1970.	No. 1971.	No. 1972.
Organic and volatile matters	2.215	2.045	5.475	4.000	2.745	2.450
Alumina and iron and manganese oxides	3.616	5.872	5.629	7.394	5.452	8.090
Lime carbonate	.110	.030	.520	.470	.070	.080
Magnesia	.106	.097	.124	.097	.079	.140
Phosphoric acid	.019	.013	.156	.141	.083	.045
Sulphuric acid	Not estimated.					
Potash	.144	160	.148	.380	.221	.219
Soda	.489	.312	.210	.175	.143	.115
Sand and insoluble silicates	92.980	90.840	85.740	85.090	90.440	88.040
Water, expelled at 380° F.	.650	.615	2.200	1.625	.865	.850
Total	100.329	99 984	100.202	99.372	100.098	100.029
Hygroscopic moisture	0.950	1.250	2.425	2.215	1.175	1.550
Potash in the insoluble silicates	.992	.958	.958	.853	1.081	1.188
Soda in the insoluble silicates	.253	.209	.314	.242	.354	.258
Character of the soil	Virgin soil	Subsoil.	New soil	Subsoil.	Old field.	Subsoil.

The unproductiveness of the soils Nos. 1967 and 1968, from the so-called Buncombe tract, finds an explanation in their chemical composition as detailed above. Both surface soil and subsoil show a very marked deficiency of phosphoric acid, the proportions of which, 0.019 and 0.013 per cent. only, are smaller than have been found in any other Kentucky soils. This deficiency alone would cause sterility; but it fortunately can be remedied quite easily by means of top-dressings of fertilizers containing phosphates, such as commercial superphosphate of lime, bone-dust, or good guano. These soils are also somewhat deficient in organic matters (humus), lime, &c., and may no doubt be greatly improved by the cultivation of clover, with top-dressings of plaster of Paris or slaked lime, and the plowing under of the green crop after one year's grazing with hogs or cattle. The relative small proportion of alumina, &c., to the sand and silicates, which makes them what are called a "hungry soil," may be measurably remedied by the judicious use of such clay marls as may be accessible. The alkalies, potash, and soda are not greatly deficient in these soils, yet the use of wood ashes, or some other alkaline fertilizer, would doubtless increase their fertility.

The soils Nos. 1969–1970 and 1971–1972, differing so greatly in productiveness—soil 1969 producing fifty to sixty

bushels of corn to the acre, and the others only twenty-five bushels—also exhibit very significant differences in their chemical composition. Taking the surface soils for comparison, we find the more productive soil, No. 1969, contains nearly twice as much organic matters and phosphoric acid as the less fertile one, No. 1971, and that this latter essential ingredient, phosphoric acid, is notably deficient in the less productive soils. Another marked difference is found in the relative proportions of lime and magnesia, the great deficiency of which in the old field soils seems to indicate that their present inferiority is probably as much owing to an original difference of composition as to the deteriorating influence of the sixty years of cultivation. This supposition is strengthened by the relatively higher proportion of potash in the old field soil.

The remarks on the improvement of the soil of the Buncombe tract apply also to this old field soil.

BARREN COUNTY.

SOILS AND SUBSOILS, &c.

No. 1973—"VIRGIN SOIL, *from the farm of Major J. S. Barlow, in the 'Barrens,' four miles east of Cave City, Barren county.*" *Collected by Rev. Herman Hertzer.*

"Geological formation: St. Louis limestone, the partly decomposed rock six feet beneath the surface. Very rich soil generally in the 'Barrens.' The 'Barrens,' so-called because of the absence of forest growth in early times, extend from Hardin county through Barren, Warren, and Simpson counties. Formerly 'prairie' land, now overgrown with a young forest of black oak, scrub oak, walnut, beech, and hickory."

The dried soil is of a light umber color. Clods friable. The coarse sieve removed from it only a small quantity of small fragments of decomposing chert and iron gravel. The silicious residue, after digestion in acids, all passed through fine bolting-cloth, except a small quantity of particles of partly decomposed silicates, and some few clear quartz grains.

No. 1974—"SOIL, *sixty years in cultivation, from the same locality as the last. Average crops: of tobacco, one thousand*

two hundred pounds; wheat, fifteen bushels; corn, forty to fifty bushels." Collected by Rev. Herman Hertzer.

The dried soil is of an umber color, slightly darker than that of the preceding soil. The clods are friable. The coarse sieve separated from it about forty per cent. in weight of angular fragments of decomposing chert. The silicious residue all passed through the fine bolting-cloth, with the exception of some small angular particles of partly decomposed silicates.

[From the comparative color and chemical composition of these two soils, it is probable that their labels were accidentally interchanged.]

No. 1975—"SUBSOIL *of the two preceding soils," &c., &c.*

The dried subsoil is of a light grey-brown color; is somewhat cloddy, the clods being firm. The coarse sieve removed from it only a few small fragments of decomposing chert. The silicious residue, after digestion in acids, all passed through fine bolting-cloth, except some small particles of partly decomposed silicates, and a few small rounded quartz grains.

No. 1976—"VIRGIN SOIL, *from the farm of Daniel Davasher, southern part of Barren county. Geological formation: silicious grit, decomposed fifteen feet deep. Forest growth: beech, hickory, oaks, poplar, and chestnut." Collected by Rev. Herman Hertzer.*

The dried soil is of a light brownish-grey color. The coarse sieve removed from it about twenty-two per cent. of coarse angular fragments of ferruginous sandstone and silicious concretions. The bolting-cloth separated from the silicious residue some silicious particles, grey, white, and flesh-colored, with a few of partly decomposed silicates.

No. 1977—"SURFACE SOIL; *in cultivation for thirty years; from the same farm as the next preceding. Yield: of corn, forty bushels; of wheat, ten to fifteen bushels; of tobacco, eight hundred pounds." Collected by Rev. Herman Hertzer.*

The dried soil is of a light dirty-buff color. The coarse sieve removed from it about seven per cent. of coarse silicious

fragments, and the silicious residue left on the fine bolting-cloth a few particles similar in character to those of the virgin soil.

No. 1978—"SUBSOIL *of the next preceding*," *&c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is of a grey-buff color. It contains about eleven per cent. of coarse angular silicious fragments and concretions, and its silicious residue gave fewer silicious particles by the fine bolting-cloth than the preceding.

No. 1979—"VIRGIN SOIL, *from the farm of Mrs. M. E. Davis, eight miles south of Glasgow, Barren county. Geological formation: silicious or Kekokuk Group. Forest growth: black walnut, beech, sugar-tree, &c., &c.*" *Collected by Rev. Herman Hertzer.*

The dried soil is of a light grey-umber color. The coarse sieve removed from it less than five per cent. of coarse angular silicious fragments and concretions. The silicious residue, from digestion in acids, all passed through the fine bolting-cloth, except small greyish, reddish, and white particles of quartz and partly decomposed silicates.

No. 1980—"SURFACE SOIL, *sixty years in cultivation; from the same farm as the preceding. Geological formation: silicious or Keokuk Group, rocks decayed to depth of twelve to fifteen feet. Average crops: of tobacco, one thousand to eleven hundred pounds; of corn, twenty-five to forty bushels.*" *Collected by Rev. Herman Hertzer.*

The dried soil is a little lighter colored and more yellowish than the preceding. The coarse sieve removed from it but a very small proportion of small angular silicious and ferruginous fragments, and the silicious residue contained fewer small silicious grains than the preceding.

No. 1981—"SUBSOIL *of the next preceding*," *&c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is of a brownish-buff color. The coarse

sieve separated from it only a very small proportion of small silicious and ferruginous gravel. The fine bolting-cloth removed from the silicious residue a considerable proportion of soft, partly decomposed silicate grains, and but few hard silicious particles.

No. 1982—"SURFACE SOIL, *sixty years in cultivation; from the same farm as the preceding. Bottom land. Inexhaustible because of annual inundation. Average crop: fifty bushels of corn.*" *Collected by Rev. Herman Hertzer.*

The dried soil is of a light brownish-umber color. The coarse sieve separated only a very small proportion of small silicio-ferruginous fragments, and the silicious residue, from digestion in acids, all passed through the fine bolting-cloth.

No. 1983—"SUBSOIL *of the next preceding*," *&c., &c. Collected by Rev. Herman Hertzer.*

The dried subsoil is slightly more brownish in tint than the preceding. The coarse sieve removed from it but a very small proportion of silicio-ferruginous gravel. Like that of the preceding, the silicious residue all passed through the fine bolting-cloth, leaving upon it no small silicious particles.

COMPOSITION OF THESE BARREN COUNTY SOILS, DRIED AT 212° F.

	No. 1973	No. 1974	No. 1975	No. 1976	No. 1977	No. 1978	No. 1979	No. 1980	No. 1981	No. 1982	No. 1983
Organic and volatile matters. . .	4.175	5.475	2.615	5.465	3.065	2.300	4.700	3.450	2.415	4.150	3.725
Alumina and iron and manganese oxides,	7.365	7.740	8.323	4.310	4.942	6.142	4.632	4.622	6.186	5.967	6.034
Lime carbonate	.215	.465	.090	.340	.225	.125	.425	.190	.190	.475	.475
Magnesia	.197	.250	.197	.047	.065	.080	.061	.061	.065	.017	.115
Phosphoric acid	.125	.275	.092	.125	.093	.093	.108	.198	.124	.093	.131
Sulphuric acid	Not estimated.										
Potash	.209	.126	.308	.184	.158	.092	.069	.126	.225	.105	.161
Soda	. . . .	.004	. . . .	.029	.053	.055	.060	.024	.086	. . . .	. . . .
Sand and insoluble silicates	86.065	82.990	86.665	87.470	90.185	89.985	87.985	89.685	89.650	87.710	87.835
Water, expelled at 380° F.	1.575	2.275	.935	1.800	1.015	.800	1.650	1.300	1.000	1.325	1.375
Total	99.926	99.600	99.225	99.770	99.801	99.672	99.690	99.656	99.941	99.842	99.851
Hygroscopic moisture.	1.865	2.500	1.775	2.150	1.500	1.700	2.100	1.650	1.735	1.800	1.900
Potash in the insoluble silicates	1.227	1.074	1.253	.934	1.102	1.179	.722	1.223	1.151	1.156	1.127
Soda in the insoluble silicates	.394	.334	.373	.300	.318	.256	.234	.381	.318	.372	.446
Character of the soil	Virgin.	Old field	Subsoil.	Virgin.	Old field	Subsoil.	Virgin.	Old field	Subsoil.	Old field	Subsoil.

The reasons for believing that the labels of soils Nos. 1973 and 1974 have been accidentally interchanged, is the greater proportions of organic matters, lime, magnesia, and phosphoric acid, and the smaller quantity of sand and insoluble silicates in 1974 than in 1973. The greater proportion of potash in the latter is also corroborative of this supposition, because the subsoil is richer in this alkali than the surface soils.

These Barren county soils are above the average in native fertility, and would require only skillful management, with a judicious rotation of crops and the occasional use of special fertilizers, as may be indicated, to keep them up to a high degree of productiveness.

BATH COUNTY.

Mineral Waters, &c., of the Olympian Springs.

The principal waters of these celebrated springs were qualitatively examined by the writer about the year 1848–'9, and the results were published in volume III of the first series of Reports of the Geological Survey of Kentucky, pages 208–210. About ten years thereafter (in 1858–'9) more extended quantitative analyses were made by him of samples of these waters, sent to his laboratory in bottles by Mr. H. Gill, the proprietor. As such analyses of the waters forwarded in bottles could not include the gases, and, moreover, were liable to accidental errors, the writer visited these springs in August last (1877), accompanied by his son, Alfred M. Peter, in order to quantitatively estimate the gases in the recent waters; to evaporate a sufficient quantity on the spot to enable him to estimate their minuter saline ingredients, and to collect with care, in very clean glass-stoppered bottles, enough of the waters of the several springs for complete quantitative analyses in his laboratory in Lexington.

The hydrogen sulphide was estimated in the recent waters at the springs, by the volumetric process, with the use of a deci-normal iodine solution, &c., and the carbonic acid, thrown down in a measured quantity of the waters, by an ammoniacal solution of barium chloride, was separated and weighed at the laboratory.

THE SULPHUR WATERS OF THE OLYMPIAN SPRINGS.

No. 1984—"SALT SULPHUR WATER." *Well at the saloon, near the main house or hotel. The water is raised by a pump in the well, which is eight to ten feet deep. The spring is said to yield about two hundred and seventy gallons per hour. The temperature of the water was found to be* 56° *F., when that of the atmosphere was* 75° *F. The water forms a slight yellowish or ochreous incrustation on the glass tumblers used at the well. It exhibits a slightly alkaline reaction.*

No. 1985—"BLACK SULPHUR WATER." *From an open well, about a quarter of a mile nearly south of the main house, in the bottom ground just at the foot of the hill. The water is confined in a barrel without heads, sunk into the ground. The temperature of the water in the barrel was* 57° *F. Its sediment is nearly black, and it exhibits a slightly alkaline reaction.*

No. 1986—"WHITE SULPHUR WATER." *From a rather feeble spring about three miles from the Olympian Springs.*

This spring was not visited by the writer, but a demijohn of the water was sent to the "Springs" by John D. Young, Esq. The hydrogen sulphide, therefore, was not estimated.

COMPOSITION OF THESE BATH COUNTY SULPHUR WATERS.

In 1000 parts of the water.

	No. 1984.	No. 1985.	No. 1986.	
Hydrogen sulphide gas	0.0011	0.0012	not est.	
Carbonic acid gas (CO_2)	0.2400	.2781	not est.	
Lime carbonate	0.1975	0.0158	0.0744	Held in solution by the carbonic acid.
Magnesia carbonate	.0506	.0046	.0316	
Baryta carbonate	.0128	.....	.....	
Strontia carbonate	.0045	.....	.....	
Iron carbonate	.0025	.0024		
Alumina	.0006	.....	.0021	
Manganese carbonate and phosphoric acid	traces.	traces.		
Lime sulphate	.0083	.0061	.0039	
Potash sulphate	.....	.0031	.0133	
Soda sulphate	.....	.0025	.0408	
Soda carbonate	traces	not est.	.3247	.3113
Calcium chloride	.0213	.....	....	
Magnesium chloride	.1089	.....	.0071	
Sodium chloride	4.8997	.1208	.1326	
Potassium chloride	.0355	.....	....	
Lithium chloride	.0008	trace.	trace.	
Sodium bromide	.0166	.....	.....	
Sodium iodide and sulphide	trace.	trace.	trace.	
Boracic acid	trace.	trace.	trace.	
Silica	.0232	.0124	.0115	
Traces of organic matter and loss,	.0340	.0164	.....	
Total saline matters in 1000 parts	5.4168	0.5088	0.6286	
Specific gravity of the water	1.004	not est.	not est.	

These interesting sulphur waters present considerable differences in their chemical composition. The salt sulphur of the saloon contains greatly more chlorides than the others, and especially much more sodium chloride (common salt) than they, while the black and white sulphurs are much more alkaline from the presence of a considerable quantity of carbonate of soda. They also contain more alkaline sulphates. All of them have a notable quantity of iron carbonate, of which chalybeate ingredient the salt sulphur and the black sulphur contain the largest proportions. The quantity in the white sulphur was not separately determined, but is doubtless quite minute.

These waters, and particularly those of the salt sulphur well, are applicable to the treatment of a great variety of chronic diseases, under judicious medical advice, combining, as they do, saline, alkaline, and chalybeate properties, with those of the hydrogen sulphide, and the bromides and iodides. They are found to be diuretic, diaphoretic, tonic, and alterative, when used internally, not usually exerting much aperient action; and when employed in the bath, for which purpose the salt sulphur is used exclusively, they are valuable in the treatment of cutaneous affections, &c.

The very small proportions of barium, strontium, aluminum, and lithium compounds, together with those of boracic and phosphoric acids, which were detected in this recent re-examination of these waters, interesting as their discovery may be to the philosopher, cannot be supposed to exert much influence in their medicinal action, yet, doubtless, they are not without effect.

Since the detection of barium and strontium compounds in these waters containing sulphates, the attention of the writer was drawn to a recent communication of M. Dieulafait to the Academy of Science of Paris, as to the very general presence of strontium carbonate or sulphate in the sea waters, as well as in limestone, gypsum, and the fossil remains of the mollusca, and saline mineral waters generally. According to his statement, only forty-four out of eight hundred of such waters, &c., failed to show distinct evidence of the presence of strontium.

On examining Liebig's analysis of the celebrated *Keiserquelle* (Emperor well), at Aix-la-Chapelle, in Rhenish Prussia, one of the most noted waters of Europe, and an early resort of the Romans, a remarkable resemblance in general composition may be seen between this and the salt sulphur water of the Olympian Springs, as the following comparative table shows:

	Salt sulphur water of Olympian Springs.	Water of Emperor Well, Aix-la-Chapelle.
Lime carbonate	0.1975	0.1580
Magnesia carbonate	.0506	.0510
Baryta carbonate	.0128	. . . . .
Strontia carbonate	.0045	.0002
Iron carbonate	.0025	.0096
Alumina	.0006	traces.
Manganese, phosphoric acid	traces.	
Lime sulphate	.0083	traces.
Potash sulphate	. . . . .	.1540
Soda sulphate	. . . . .	.2830
Soda carbonate	traces.	.6500
Lithia carbonate	. . . . .	.0003
Lithium chloride	.0008	. . . . .
Calcium chloride	.0213	. . . . .
Magnesium chloride	.1089	. . . . .
Sodium chloride	4.8997	2.6390
Potassium chloride	.0355	. . . . .
Sodium bromide	.0166	.0036
Magnesium bromide	. . . . .	.0006
Sodium sulphide	traces.	.0195
Sodium iodide	traces.	traces.
Boracic acid	traces.	. . . . .
Silica	.0232	.0661
Organic matters, &c.	.0340	.0752
Total saline matters in 1000 parts	5.4168	4.1020
Temperature	56° F.	131° F.

The Aix-la-Chapelle are hot springs, and the water contains more alkaline sulphates and carbonates, with less of chlorides and bromides, than our salt sulphur water; but the general resemblance of their chemical composition is close, especially as they contain nearly the same gaseous ingredients.

One object in view in the re-examination of the Olympian Spring waters was to ascertain whether their proportion of saline matters had been diminished in the lapse of nearly twenty years since the first analyses were made by the writer. It is interesting to see that no notable change in this respect has occurred. (*See vol.* 4, *p.* 69, *Reports Geological Survey of Kentucky, first series*). The slight apparent difference being probably due to less perfect drying of the total saline matters in the former analyses.

CHALYBEATE MINERAL WATERS OF THE OLYMPIAN SPRINGS

No. 1987—"MAIN CHALYBEATE SPRING; *in a valley, about half a mile north of the main building, Olympian Springs.*"

The water runs, over a wooden gutter, out of the ferruginous magnesian limestone, which lies under the Devonian shale, at the base of the hill, about four feet above the bed of the so-called "Chalybeate Branch," which runs into Mud Lick. The spring yields about three litres of water per minute (*i. e.*, somewhat more than three quarts). The temperature of the water is 54° Fahrenheit. It deposits a sediment in its channel of outflow, which is of a ferruginous-brown color. The water, as it flows out of its source, is remarkably clear, but exposure to the air, by the removal of carbonic acid and the substitution of oxygen, converts the dissolved iron carbonate into the hydrated peroxide, which is insoluble in water.

The dried *ferruginous sediment*, on analysis, was found to contain about 65 per cent. of *iron peroxide*, about 20 per cent. of *soluble silica*, with notable proportions of *lime* and *magnesia carbonates*, and traces of *manganese*, *phosphoric* and *apocrenic acids*. Hydrosulphuric acid did not detect the presence of arsenic or any metal of that group.

No. 1988—"CHALYBEATE SPRING, *flowing out of a crevice in the ferruginous magnesian limestone in the bed of the Chalybeate Branch, about sixty yards above the main chalybeate spring above described.*"

It deposits a ferruginous sediment in the bed of the branch of a light brownish-orange color.

COMPOSITION OF THESE OLYMPIAN SPRING CHALYBEATE WATERS.

In the 1000 parts.

	No. 1987	No. 1988	
Free carbonic acid gas	0.1214	0.1269	
Iron carbonate	0.0242	0.0100	Held in solution by the free carbonic acid.
Lime carbonate	.0998	.0890	
Magnesia carbonate	.0143	.0103	
Manganese carbonate	trace	trace.	
Phosphoric acid	trace.	trace.	
Lime sulphate	.0554	.0366	
Magnesia sulphate	.1170	.0693	
Potash sulphate	.0125	.0117	
Soda sulphate	. . .	.0238	
Sodium chloride	.0308	.0060	
Magnesium chloride	.0031	. . .	
Lithium chloride	trace.	trace.	
Apocrenic acid	trace.	trace.	
Silica	.0332	.0198	
Loss	.0194	.0168	
Total saline matters in 1000 parts of the waters	0.4097	0.2935	

The main chalybeate spring water is in every respect very good of its kind, and may be used in all cases in which chalybeate remedies are indicated. The principal difference in composition between the two springs is, that the main spring is more than twice as strong in iron carbonate, making it a better chalybeate remedy than the other. It also contains more sulphate of magnesia, but less sulphate of soda. They form a valuable addition to the Olympian Springs.

As the chalybeate and other saline ingredients of these waters seem evidently to have been derived mainly from the ferruginous magnesian limestone out of which they flow, and which the waters have worn and perforated in a remarkable manner, the writer collected some of the limestone and submitted it to analysis, with the following result:

No. 1989—FERRUGINOUS MAGNESIAN LIMESTONE, *out of which flow the chalybeate springs above described, as well as many others in this region, and which forms the bed of the Chalybeate Branch, at and near those chalybeate springs. It lies immediately under Black Devonian Shale. Collected by Robert Peter.*

369

A crystalline-granular limestone; grey, of various tints, in the interior—generally light grey; light ferruginous or brownish-ochreous on the exterior. Adheres slightly to the tongue, and is more or less porous. The water has worn it irregularly, and in some places perforated it by enlarging the small crevices or cavities in it.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	54.000
Magnesia carbonate	34.027
Iron carbonate	11.532
Phosphoric acid	.006
Potash	.143
Soda	040
Silica	.280
Total	100.028

The main agent in the solution of this ferruginous limestone is, undoubtedly, the carbonic acid dissolved in the water which flows over or percolates it. The greater part of this carbonic acid is no doubt derived from the gradual decomposition of the vegetable matters on the surface of the hill at the base of which the springs and this rock are located. At present this and the neighboring hills are covered with the primeval pine forest, which keeps the surface continually covered with its vegetable *débris*, which, by slow decomposition and oxidation, yields an abundance of carbonic acid to the atmospheric water which falls upon it, thus making it, what the pure water itself is not, a good solvent of the iron and other carbonates of the ferruginous magnesian limestone beneath. It appears, therefore, that the character or strength of these springs is greatly dependent on the forest growth on the surface of the hill or hills above them; and that if these woods on the hills above should be at any time cleared off, and the surface of the land deprived of its present carpet of decaying vegetable matters, the springs would measurably lose their strength and value. Another deplorable result from clearing off these woods and bringing the soil into arable culture would be, that more of the atmospheric water would run off from the surface of the hills, and less of it would sink into the depth of the soil and

subsoil to feed springs; so that, if the springs were not entirely dried up, except in a rainy season, their outflow would be greatly diminished. Moreover, the beauty, salubrity, and attractiveness of this favorite sylvan watering-place depend greatly on the native pine forest which clothes the neighboring hills.

In addition to the sulphur, salt sulphur, and chalybeate waters of this locality, there are others, saline and alkaline, of various qualities, deriving their dissolved ingredients, some from the salts of the primeval ocean under which the rocks were deposited, some from the action of the atmospheric waters and gases on the Devonian and other strata. One of the oldest known, which formerly was called a salt lick, to which the wild denizens of the forests resorted, and around which the buffaloes made their wallows, may be described as follows:

No. 1990—"SALT WATER *from the old well at the original Salt Lick, near the remains of the old barracks of the volunteers of* 1812, *about one hundred to one hundred and fifty yards south from the main house.*"

The water flows out in a small stream, running into Mud Lick creek. The ground about is covered with an efflorescence of salt. The water tastes like that of the salt sulphur well, but it has only a slight odor of hydrogen sulphide.

COMPOSITION OF THIS SALT WATER.

Carbonic acid gas, not estimated; hydrogen sulphide, a trace. In 1000 parts of the water.

Lime carbonate	0.1844	Held in solution by the carbonic acid.
Magnesia carbonate	.0458	
Baryta carbonate	.0099	
Strontia carbonate	.0045	
Iron and manganese carbonate, and phosphate	.0019	
Lime sulphate	.0036	
Soda carbonate	.2241	
Calcium chloride	.0152	
Magnesium chloride	.1188	
Sodium chloride	4.7121	
Potassium chloride	.0375	
Lithium chloride	trace.	
Bromine, boracic acid	trace.	
Silica	.0232	
Loss	.0130	
Total saline contents in 1000 parts of the water	5.3940	

371.

This water resembles that of the salt sulphur well in the relative proportions of its common salt and other chlorides; but it is more decidedly alkaline, because of its larger proportion of carbonate of soda, and contains less of bromine and lithium compounds. Moreover, it is almost destitute of hydrogen and sodium sulphides, which give a distinctive character to the salt sulphur water. On examining volume IV of the Reports of the Geological Survey of Kentucky, first series, for the former analysis of this water, the writer finds that a transposition of the labels on the bottles in which the waters were sent to the laboratory by Mr. Gill must have occurred (see pages 71, 72), so that the label "salt water," &c., &c., was placed on the bottle which contained the so-called "cooking water," and *vice versa*. The analysis No. 803, page 72, agrees pretty well with the present in the principal ingredients and the total saline contents. This now published is of course more complete and accurate.

THE ALKALINE SALINE WATERS OF THE OLYMPIAN SPRINGS.

No. 1991—WATER *from the well at the kitchen door of the main house; about eight feet deep; yields about one hundred and thirty-five gallons per minute. The water is raised with a wooden pump.*

It is slightly alkaline in reaction, and deposits a slight ochreous sediment in the bottle. Tastes somewhat chalybeate, and smells and tastes faintly sulphurous. This water is used for all ordinary purposes of the kitchen and household, as well as for drinking.

No. 1992—WATER, *called "Tea Water," from a spring or open shallow well, on the border of Mud Lick creek, about half a mile south of the main house, and above it on the stream.*

The spring is inclosed in two no-headed barrels, placed the one on top of the other, and is about four feet deep. The water was not overflowing. Temperature of the water, 62°. Reaction slightly alkaline. As there had been rain shortly before the sample of the water was obtained for analysis, it may possibly be weaker than usual.

COMPOSITION OF THESE WATERS.

In 1000 parts of the water.

	No. 1991.	No. 1992.	
Carbonic acid gas	not est.	not est.	
Hydrogen sulphide gas	a trace.	none.	
Lime carbonate	0.0556	0.0241	Held in solution by carbonic acid.
Magnesia carbonate	.0277	.0059	
Strontia carbonate or sulphate	trace.	trace.	
Iron and manganese carbonates and phosphates	.0054	.0022	
Lime sulphate	.0065	.....	
Soda sulphate	.0208	.....	
Potash sulphate	.0285	.....	
Sodium chloride	.1483	.0377	
Potassium chloride	.....	.0039	
Magnesium chloride	.0047	.....	
Soda carbonate	.5431	.4479	
Sodium sulphide	trace.	.....	
Lithia, boracic acid	trace.	trace.	
Silica and loss	.0280	.0315	
Total saline contents in 1000 parts	0.8686	0.5532	

Although these waters do not contain a very large proportion of saline matters, yet their alkaline and slightly chalybeate properties may make them available as diuretic, depurative, tonic, and alterative remedial agents. Many celebrated alkaline waters are not stronger in saline and gaseous contents than these. These examinations and analyses were made in August, 1877; on reëxamining the water from the well at the kitchen door, No. 1991, in February, 1878, after rather a wet season, the water was found to be at least one third weaker in saline contents.

No. 1993—"WATER, *from an 'Epsom Well,' about three quarters of a mile northeast of Olympian Springs, on the farm of Mr. Robinson.*"

The well is about twenty feet deep, walled up with stone. The water is used by the family for drinking and all domestic purposes, and they have become accustomed to it, so that it produces no sensible effect upon them. Mr. Robinson had turned the rain water from the roofs of his houses into the well, so that the water obtained for examination had been

much weakened by the result of a recent rain; hence a quantitative analysis was not made of it. It tasted strongly of Epsom salt, and gave decided evidence, by the usual tests, of the presence in it of much *magnesia* and *sulphuric acid*, considerable *lime* and *chlorine*, and traces of *iron*, &c., &c.

The old "Epsom Well," the water of which had been analyzed and reported by the writer in volume IV, page 70, of Reports of the Geological Survey of Kentucky, first series, had been filled up; but Mr. Robinson will probably reopen it. This aperient water would be a valuable addition to the considerable variety of the mineral waters of the Olympian Springs, especially as the other waters do not generally exert a laxative action.

BRECKINRIDGE COUNTY.

No. 1994—"MARLY SHALE, *from Tar Creek Hill; Bowling Green road, near Cloverport, Breckinridge county.*" *Collected by P. N. Moore.*

A friable shale; of a yellowish olive-grey color; containing many minute specks of mica. Before the blow-pipe it fuses into a dark colored slag. Burns of a handsome bright brick color.

COMPOSITION, DRIED AT 212° F.

Silica	66.960
Alumina	15.626
Iron oxide	8.380
Lime	.493
Magnesia	.677
Phosphoric acid	.154
Potash	3.295
Soda	.628
Water, carbonic acid, and loss	3.787
Total	100.000

This marly shale would no doubt be useful as a fertilizer on old exhausted soils of a light and sandy nature. Exposed to the frosts on the surface of the ground, it would very probably undergo complete disintegration. Its considerable proportion of potash would gradually become available for vegetable nourishment under the influence of the atmospheric

agencies, but might perhaps be brought more quickly into use by the simultaneous application of slacked lime on a clover crop. It might be used for *terra cotta.*

BUTLER COUNTY.

No. 1995.—"COAL *from 'Mining City Coal Bank,' recently opened; owned by the Green and Barren River Navigation Company. Mouth of Mud Creek. Bed thirty-six to thirty-nine inches thick. Average sample.*" *Sent from Frankfort by John R. Procter.*

A pure-looking coal, breaking into thin laminæ, with fibrous coal and very little fine-granular pyrites between. Specific gravity not determined.

COMPOSITION, AIR-DRIED.

Hygroscopic moisture	3.28
Volatile combustible matters	44.20
Spongy coke	52.52
Total	100.00
Total volatile matters	47.48
Fixed carbon in the coke	48.56
Dark lilac-grey ash	3.96
Total	100.00
Percentage of sulphur	3.060

A very good splint coal, resembling the "block coal" of Indiana, yielding quite a small proportion of ash, and containing no inordinate quantity of sulphur.

No. 1996.—"MARLY CLAY SHALE OR INDURATED CLAY. (*Fire-clay?*) *Below the coal at the Mud Creek Mines. Collected by John R. Procter.*"

Of a dark-grey or lead color, imperfectly and irregularly laminated. Contains many minute specks of mica, and some imperfect impressions, apparently of marine shells. It is quite

plastic when powdered. Burns of a light yellowish-grey color, nearly white, hence might be made available in *terra cotta.* Fuses before the blow-pipe.

COMPOSITION, DRIED AT 212° F.

Silica	51.660
Alumina	15.560
Iron oxide	7.680
Lime	7.269
Magnesia	.817
Phosphoric acid	not est.
Potash	3.276
Soda	.293
Water, carbonic acid, organic matters, and loss	13.445
Total	100.00

Its large proportions of iron oxide, lime, and alkalies render it easily fusible at a high temperature.

FAYETTE COUNTY.

No. 1997.—"WATER *from a bored well about* 80 *to* 90 *feet deep, on the site of the Lexington Depot of the Cincinnati Southern Railroad, about three quarters of a mile from the Court-house." Collected by Mr. C. J. Norwood and Mr.* ——— *Totten, Civil Engineer.*

The water is perfectly limpid and colorless, has a slight petroleum-like odor, but contains no hydrogen sulphide.

No. 1998.—"WATER *from the same well after it had been deepened to one hundred and fifty-three feet and a half. Sent by Chas. A. Tasker, Resident Engineer on the C. S. R. R., at Lexington.*"

The water is yet clear, inodorous, and tasteless; like the former sample, it gave a slightly alkaline reaction.

The object of the analyses was to ascertain the availability of this water for use in boilers of the locomotives of the railroad.

COMPOSITION IN 1000 PARTS OF THE WATER.

	No. 1997.	No. 1998.	
Lime carbonate	0.0404	0.0358	Held in solution in the water by carbonic acid, the proportion of which was not estimated.
Magnesia carbonate	.0066	.0189	
Silica	.0138	.0058	
Iron oxide, phosphoric acid, strontia carbonate	trace.	. . . .	
Lime sulphate	.0126	.0240	
Potash sulphate	.0118	.0205	
Soda sulphate	.0385	.0058	
Magnesium chloride	.0097	.0501	
Sodium chloride	.0514	.0612	
Soda carbonate	.1252	.1530	
Silica	.0218	.0036	
Lithia Organic matters	trace.	. . . . .	
Total saline matters in 1000 parts	0.3318	0.3787	

The water became very slightly stronger in saline matters by deepening the well, but its character was not materially altered. From its alkaline nature, owing to the presence in it of a certain proportion of carbonate of soda, the writer predicted that it would prove eminently fit for use in the steam-boiler, and that any sediment which might be deposited would not be likely to form a hard incrustation. Subsequent practical experience has verified this prediction. The material in the supply water which causes the hardest and worst crust in the steam-boiler is the lime sulphate or gypsum; as this is only slightly soluble in water, and is much less soluble in the very hot water of the high-pressure boiler than it is in cold water, its presence in the feed-water is greatly feared by the locomotive engineer. This injurious substance dissolves in about five hundred parts of cold water; but when subjected to the heat corresponding with four atmospheres of pressure in the steam-boiler, or one hundred and twenty pounds to the square inch, it deposits a crust, although contained in 1000 parts of water.

In the stronger of these waters the sulphate of lime is only in the proportion of about one part to forty thousand of the water; and, consequently, it would not probably form any crust until the water was evaporated to one fortieth its orig-

inal volume, even if unaccompanied by any decomposing agent. But in this water, as soon as the free carbonic acid is separated by the heat, the excess of carbonate of soda present decomposes the sulphate of lime, producing a powdery precipitate of carbonate of lime, and an equivalent amount of sulphate of soda, which remains dissolved in the water. Perfect immunity from boiler-crust may generally be secured by blowing off the residual water of the boiler at proper intervals, varying in length according to the character of the water used.

In this connection, it may be of interest to give the elevation of this well above sea level, as communicated by Geo. B. Nicholson and Chas. A. Tasker, civil engineers on the Cincinnati Southern Railroad, as follows:

Elevation of the top of this well above sea level, 964 feet.

Elevation of the bottom of the bore which furnished the water for the first analysis, 876 feet.

Elevation of the bottom of the bore which furnished that for the second analysis, 802 feet.

Elevation of the top of the well at the Lexington fair grounds above sea level, 974 feet 3 inches.

SOILS OF FAYETTE COUNTY.

No. 1999—"SURFACE SOIL, *from the lawn at Ashland, near Lexington, homestead of the late Henry Clay, near Lexington, Kentucky.*" *Collected by John H. Talbutt.*

The dried soil is of a dark brownish-umber-grey color. It all passed through the coarse sieve except numerous rootlets and some small, friable, shot iron ore. It appears to contain no sand. The silicious residue from two grammes, left after digestion in acids, all passed through fine bolting-cloth except a single small grain of clear quartz, and some small, soft, rounded particles of partly decomposed silicates.

No. 2000—"SUBSOIL *of the next preceding*," *&c., &c.*

The air-dried subsoil is a little lighter colored and more brownish than the surface soil. The clods are somewhat more adhesive. It contains a considerable proportion of fria-

ble shot iron ore. The silicious residue gave a single minute grain of transparent quartz only, when passed through the fine bolting-cloth.

COMPOSITION OF THESE FAYETTE COUNTY SOILS, DRIED AT 212° F.

	No. 1999.	No. 2000.
Organic and volatile matters	4.325	3.535
Alumina and iron and manganese oxides	12.168	15.666
Lime carbonate	.295	.345
Magnesia	.214	.331
Phosphoric acid	.492	.604
Sulphuric acid	not est.	not est.
Potash	.268	.372
Soda	.038	. . . . .
Sand and insoluble silicates	80.090	77.715
Water, expelled at 380° F.	1.800	1.300
Total	99.690	99.868
Hygroscopic moisture	2.850	3.375
Potash in the insoluble silicates	1.343	1.273
Soda in the insoluble silicates	.359	.332
Character of the soil	Surface soil	Subsoil.

These present all the characteristics of our rich "blue-grass" or blue limestone soils. In the first place, they contain no gravel, pebbles, coarse sand, or even what might generally pass for fine sand, the whole being in such a state of fine division that, when the soft clods are disintegrated, by the action of water or otherwise, it will pass through fine bolting-cloth; yet, because of the presence of more than three fourths of its weight of exceedingly fine silicious material, water does not lodge on it, but readily passes through it, so that it is easily drained; and, because of the clefts and crevices in the limestone sub-stratum, it is usually naturally drained through the numerous subterraneous caverns and channels of the rock on which it rests.

These soils, moreover, present more than the usual proportion of phosphoric acid, and large proportions of the alkalies,

potash, and soda, which aid in giving to them a very durable fertility. The proportions of alumina and iron oxide, of humus, &c., are such as characterize our richest soils.

PHOSPHATIC LAYERS IN THE LOWER SILURIAN LIMESTONE OF FAYETTE COUNTY.

In volume IV, new series, of Reports of the Geological Survey of Kentucky, on pages 65 and 66, mention is made and the analysis given, of a specimen of phosphatic limestone extraordinarily rich in phosphoric acid. As the quarry from which it came was not then in use, and the face of it had been covered by fallen earth, the correctness of the statement of the quarryman, to the effect that a layer of similar material was sometimes as much as a foot in thickness in this quarry, could not at that time be easily tested.

Other specimens of rock of similar external qualities, from the neighborhood of this quarry, were examined; and when the quarry was again opened and worked for turnpike material, in the autumn of 1877, a more complete examination was made by the writer, the results of which are given below.

No. 2001—"PHOSPHATIC LIMESTONE, *a layer in the Lower Silurian 'Blue Limestone' formation; taken from a shallow well at the Wine House at Winton, farm of Robert Peter, about six and a half miles north from Lexington, on the Newtown Turnpike. Collected by R. Peter.*"

In thin fissile layers, of a dark olive-slate color, between the harder, greyish-blue, more crystalline limestone layers. It contains many minute fossils, especially spiral shells.

No. 2002—"PHOSPHATIC LIMESTONE, *from a quarry on the farm of John Keiser, on the north side of the Newtown Turnpike, about six miles from Lexington. Collected by R. Peter.*"

Sample taken from the roadside, where it had been placed for turnpike purposes. It is of a dull, bluish-slate color, and is quite fissile. It does not contain so many small fossils as the next preceding.

COMPOSITION OF THESE PHOSPHATIC LIMESTONES, DRIED AT 212° F.

	No. 2001.	No. 2002.
Lime carbonate	78.040	57.440
Magnesia carbonate	2.332	7.327
Alumina and iron and manganese oxides	4.017	8.716
Phosphoric acid	2.623	1.462
Silicious residue	9.891	21.784
Alkalies, sulphuric acid, water, &c., &c.	3.097	3.271
Total	100.000	100.000

No. 2003—"PHOSPHATIC LIMESTONE, *from the same quarry, on the northwest side of the Newtown Turnpike, about three miles north of Lexington, from which the very rich specimen was taken described on pages* 65 *and* 66 *of the 4th volume, new series, of Kentucky Geological Reports. Collected by Robert Peter.*"

Taken from irregular layers, about one foot in thickness, near the base of the quarry, say from four to six feet below the surface of the rock, which is covered with about four feet of earth, on the ridge or hill in which the quarry is located. These layers are of a dark-grey color, of various thickness, mixed more or less with lighter-grey crystalline layers. The dark-grey portion adheres strongly to the tongue, absorbs water freely; it is quite tough in the mass, but somewhat friable in the small fragments, and contains small organic remains, principally fragments of brachiopod shells, some small gasteropods, and occasionally fragments of trilobite crusts.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	49.160	
Magnesia carbonate	.090	
Phosphates, with alumina, iron oxide, &c.	46.540	Containing 21.018 phosphoric acid.
Silicious residue	2.820	
Organic matters and loss	1.390	
Total	100.000	

As it was evident, from the analyses already made, that the phosphoric acid was quite irregularly diffused throughout these irregular layers, eleven several samples were selected from portions of this phosphatic layer which had been quarried and

hauled out to be broken up for the turnpike, described as follows, viz:

No. 2004—SPECIMEN 1*a*.—A somewhat crystalline layer, about one and three quarters inch thick, of a dull bluish-grey color; attached to layer 1*b*, which was darker colored (lead colored), more dull, and less crystalline than 1*a*.

SPECIMEN 2 is probably a continuation of 1.

SPECIMEN 3, probably a continuation of the same combined layer, contained a portion of a trilobite shield, which was not included in the portion analyzed.

SPECIMEN 4.—A thin layer, weathered of a light buff color.

SPECIMEN 5.—A dark bluish-grey or lead-colored layer; like 1*b*, coarse granular, and dull.

SPECIMEN 6*a*.—The dark grey unweathered portion of a layer which was weathered on one surface to a grey-buff color, showing the minute whorled univalve fossil shells very distinctly.

SPECIMEN 6*b*.—The buff, weathered portion of this layer.

SPECIMEN 7.—A thin layer weathered on the two surfaces; moderately dark grey in the interior; more dense than specimen 1; contains the minute univalve fossils.

8.—A thin crystalline layer, of a light grey color, with not much appearance of fossil remains.

9.—A coarser-grained layer, containing fossil remains; somewhat crystalline, and partly weathered.

These eleven samples were severally treated for the determination of phosphoric acid alone. One gramme of each, dried at 212° F., was digested in nitric acid with a little chlorhydric, and then, after evaporation to dryness, the residue was digested for some hours in nitric acid, diluted and filtered. The phosphoric acid was then determined by a careful use of the molybdic acid process, and the results obtained were as follows, viz:

PERCENTAGE OF PHOSPHORIC ACID IN THESE ELEVEN SAMPLES.

In sample 1*a* contained 7.931 per cent. of phosphoric acid.
In sample 1*b* contained 19.183 per cent. of phosphoric acid.
In sample 2 contained 17.973 per cent. of phosphoric acid.
In sample 3 contained 11.501 per cent. of phosphoric acid.
In sample 4 contained 21.940 per cent. of phosphoric acid.
In sample 5 contained 18.421 per cent. of phosphoric acid.
In sample 6*a* contained 20.021 per cent. of phosphoric acid.
In sample 6*b* contained 11.705 per cent. of phosphoric acid
In sample 7 contained 16.502 per cent. of phosphoric acid.
In sample 8 contained 5.053 per cent. of phosphoric acid.
In sample 9 contained 13.624 per cent. of phosphoric acid.

It will be seen that the *maximum* proportion, that in No. 4, is 21.940 per cent.; the *minimum*, in No. 8, is 5.053 per cent., and the *general average* proportion 15.896 per cent.

The greatly varying proportions of this ingredient, within small limits, point to a very irregular local origin.

Frequently the phosphoric acid of the ancient limestone layers is traceable to the brachiopod and other shells and fossils which they contain. In order to ascertain how much of it in the specimens examined is attributable to this source, the specimens described below were collected and analyzed, viz:

No. 2005—"FOSSIL SHELLS, *mostly Orthis testudinaria, from Lower Silurian limestone layers. Farm of R. Peter, about seven miles north of Lexington, near Elkhorn creek.*"

No. 2006—"FOSSIL BRANCHING CHŒTETES, *from the same locality. Collected by R. Peter.*"

Specimen 2005 yielded only 1.317 per cent. of *phosphoric acid*, and contained 11.04 per cent. of silicious matter.

Specimen 2006 gave only 0.294 per cent. of *phosphoric acid*, and 6.16 per cent. of silicious matters.

Evidently there must have been some other source of the abundant phosphates of these layers than the shells of the mollusca, or the corals. Possibly they may have been accumulated by some process of segregation; possibly they may be due to the fortuitous presence of some of the large animals of the ancient seas, which, subsisting on the more simple forms of organic life, may have left their excretions and exuviæ in these localities.

However this may be, while the examination of these layers of our limestone develops an unexpected richness in phosphates, their too irregular distribution amongst the poorer layers may make their special application to the manufacture of fertilizers too practically expensive or precarious.

FRANKLIN COUNTY.

No. 2007—"POTTER'S CLAY, *from a bed several feet in thickness, in the bottom land, in what is supposed to be an old prehistoric channel of the Kentucky river, half a mile north of Frankfort. Collected by Jno. R. Procter.*"

The specimen is part of an unburnt vessel made of the clay at the pottery. The clay is of a grey-drab or neutral tint; it contains some very small specks of mica and of ferruginous matter. It calcines of a very light brick color. Fuses before the blow-pipe.

COMPOSITION, DRIED AT 212° F.

Silica	69.300
Alumina, with iron and manganese oxides	21.780
Lime carbonate	.158
Magnesia	.331
Phosphoric acid	.060
Potash	2.351
Soda	.585
Water and loss	5.435
Total	100.000

Ten grammes of the clay, dried at the common temperature, washed quickly with water, gave 2.45 grammes of *fine sand*, containing some larger, rounded quartz grains.

This clay, while fitted for the manufacture of ordinary pottery ware, is not sufficiently refractory to be used as a fire-clay.

GRANT COUNTY.

In an investigation made by Mr. C. J. Norwood of the character of the subsoils, under-clays, and other earthy material, excavated in making some of the deep cuts on the line of the Cincinnati Southern Railroad in this county, the samples described below were collected by him, and sent to the Chemical Laboratory for analysis.

No. 2008—"MATERIAL, *from just below the top soil, extending in thickness from eighteen inches to two feet, down to the surface of the material claimed to be "Hard Pan," next below described, at section* 29, *in the cut at station* 295 *on the C. S. R. R.*"

Quite a tough clayey material, generally of a light grey-buff color when dry, mottled with light grey, and penetrated in all directions with what appear to have been vegetable rootlets, now mainly decomposed, and of a deep manganese oxide color.

No. 2009—"MATERIAL, *claimed to be 'Hard Pan,' beginning at two feet below the surface and extending to the bed-rock.*"

Rather more tough than the preceding, which it resembles in color, except that it has more of the light grey mottling and less of the manganese-like infiltrations. The bolting-cloth separated, from the silicious residue of these two under-clays, only a very few quartz grains.

No. 2010—"TOP SOIL, *from an old field owned by the heirs of Richard Dickerson. Section* 30, *cut at station* 337 *on the C. S. R. R.*"

Dried soil of a light grey-brown color; friable.

No. 2011—"SOIL, *from just below the top soil, from the same locality as the next preceding,*" *&c., &c.*

This dried subsoil, of a firmer, more clayey consistence than the preceding, is of a nearly uniform grey-buff color, mottled somewhat with light bluish-grey, and with some manganese oxide-like infiltrations.

No. 2012—"SUBSOIL, *from the same locality as the two preceding, from just below the next preceding, to the depth of two feet.*"

A clayey subsoil, grey-buff, mottled with light bluish-grey, with some dark-colored manganese oxide infiltrations. Very much like 2008 and 2009, but not so tough as these.

No. 2013—"SUBSOIL OR UNDER-CLAY, *seven inches thick, from the same locality, and immediately below the next preceding*," *&c.*

Resembles the next preceding, but shows more manganese infiltrations, with some small spheroidal concretions of the same, forming blackish spots.

No. 2014—"SUBSOIL OR UNDER-CLAY, *from the same locality, one foot thick, lying immediately below the next preceding.*"

This is a very tough clay-like material, darker in color than the next preceding; of an ochreous greyish-brown tint, with some little mottlings of bluish-grey, and some manganese-like infiltrations.

No. 2015—"SUBSOIL OR UNDER-CLAY, *from the same locality, one foot thick, lying just below the next preceding, and immediately above the bed-rock.*"

This is also quite a tough material, showing more mottling with bluish-grey clay than the preceding, and some manganese infiltrations, and containing some small calcareous nodules.

The bolting-cloth separated from the silicious residues of all these six subsoils or under-clays a considerable proportion of dull, angular fragments of what appeared to be hard silicates, which had not been decomposed by the acids in which they had been digested in the process of analysis.

COMPOSITION OF THESE EIGHT GRANT COUNTY SOILS, SUBSOILS, &c., DRIED AT 212° F.

	No. 2008	No. 2009	No. 2010.	No 2011.	No. 2012.	No. 2013.	No. 2014	No. 2015.
Alumina and iron and manganese oxides	13.849	12.675	6.847	9.199	11.672	12.564	15.237	24.465
Lime carbonate	1.420	1.465	.200	.190	.165	.225	2.290	9.425
Magnesia	.513	.600	.420	.420	.398	.609	.383	.286.
Phosphoric acid.	.636	.435	.188	.086	.188	.236	.823	.589.
Potash	.952	.780	.568	.156	.579	.259	1.124	.669.
Soda	.082	.617	.317	.368	.104	.246	.019	.245.
Water and organic matters lost on ignition	5.515	5.400	5.425	4.100	4.450	5.600	4.950	4.425
Sand and insoluble silicates	77.640	78.965	86.165	85.460	82.490	80.115	75.240	59.940
Total	100.607	100.937	100.130	99.979	100.046	99.854	100.066	100.044
Hygroscopic moisture	5.710	5.950	2.750	3.400	3.825	5.950	6.575	5.250.
Potash in the insoluble silicates	2.524	2.511	1.687	1.958	1.533	2.004	2.410	2.703
Soda in the insoluble silicates	.499	1.214	.388	.260	.638	.397	.407	.265.
Character of the sample	Subsoil.	Under-clay.	Soil.	Subsoil.	Under-clay.	Under-clay.	Under-clay.	Under-clay.

Subsoils 2008 and 2009, from the same locality, resemble each other, nearly, in chemical composition; their great toughness, mainly due, no doubt, to their large proportions of alumina, may be partly owing to their peculiar mode of aggregation. Their composition, with the exception of the absence of any notable quantity of *humus*, is that of our richest soils; but their physical condition is no doubt unfavorable to fertility. These, as well as the six other samples, were doubtless derived mainly from the so-called "mudstone" strata of the Lower Silurian formation. In these latter samples a regular increase, in the proportion of the aluminous materials, may be observed, as the depth from the surface increases, indicating probably the influence of the infiltration of surface waters. In nearly all of these clays there are large proportions of phosphoric acid and potash.

Other similar samples, collected by Mr. Charles J. Norwood, from the deep cuts of this railroad in Grant county, are described below, as follows:

No. 2016—"SUBSOIL, *twenty-one inches thick, just below the top soil, which is one foot thick. In front of Mrs. Mary Renslaer's house. Section* 33. *Second cut from the north end of the C. S. R. R., Grant county.*"

Dried subsoil in yellowish-brown, somewhat friable clods. Some little mixture of light ash-grey material observable in it.

The bolting-cloth removed, from its silicious residue, a considerable proportion of soft granules of partly decomposed silicates, but no silicious particles.

No. 2017—"UNDER-CLAY, *from the same locality, eighteen inches thick, lying immediately under the preceding subsoil, and extending down to the underlying limestone*," *&c.*

This resembles the preceding generally, in color, but is much more tough, and has some dark ferruginous or manganese discolorations, and a little more of the light colored material.

The silicious residue also contains a large proportion of soft, partly decomposed silicate granules.

No. 2018—"SURFACE SOIL, *to the depth of fifteen inches. Section 34. Second cut from the south end, C. S. R. R.,*" *&c.*

A friable earth of a light grey-umber color, containing a few dark concretions. The silicious residue all passed through the bolting-cloth, except a few soft granules of partly decomposed silicates.

No. 2019—"SUBSOIL, *from the same locality as the last, nineteen inches thick, next below the surface soil,*" *&c.*

A somewhat friable subsoil, having a more ferruginous tint than the preceding, and showing some dark colored infiltrations. Silicious residue like the preceding.

No. 2020—"UNDER-CLAY, *one foot thick, same locality as the preceding,*" *&c.*

A somewhat tough clay. Mottled, with light grey-ferruginous of various tints, and nearly black infiltrated manganese oxide. Silicious residue like the preceding.

No. 2021—"UNDER-CLAY, *eighteen inches thick, just below the preceding,*" *&c., &c.*

A tough clay; mottled like the preceding.

No. 2022—"UNDER-CLAY, *two feet thick, on the bed rock, same locality as the preceding,*" *&c., &c.*

Mottled like the preceding. Some parts of it compact and laminated. Contains occasional fragments of limestone and sandstone. Silicious residue like the preceding.

COMPOSITION OF THESE SOILS, SUBSOILS, &c., DRIED AT 212° F.

	No. 2016.	No. 2017.	No. 2018	No. 2019	No. 2020.	No. 2021.	No. 2022.
Alumina and iron and manganese oxides	17.502	27.353	9.540	10.222	18.593	15.437	11.792
Lime carbonate	1.115	4.555	.575	.290	.275	1.225	8.240
Magnesia	.151	.266	.312	.266	.402	.679	.824
Phosphoric acid	.473	.457	.345	.313	.393	.473	.793
Potash	.809	1.585	.587	.150	.611	.809	1.778
Soda	.052	.125	. . . . .	. . . . .	.165	.066	.359
Water and organic matters lost on ignition	5.365	4.675	5.675	3.780	6.290	6.085	4.290
Sand and insoluble silicates	75.090	60.967	83.790	84.890	73.575	75.890	71.924
Total	100.557	99.983	100.824	99.911	100.304	100.664	100.000
Hygroscopic moisture	not est.	not est.	not est.	not est.	not est.	not est	not est.
Potash in the insoluble silicates	1.542	1.487	1.679	1.881	1.489	2.428	2.423
Soda in the insoluble silicates	.297	.212	.510	.552	.486	.376	.324
Character of the sample	Subsoil.	Under-clay.	Surface soil.	Subsoil.	Under-clay.	Under-clay.	Under-clay.

These seven soils, subsoils, and under-clays present a general resemblance, in composition as well as in physical character, to the eight described above. The same remark will apply to the six remaining samples described below, from section No. 35, on the same railroad.

No. 2023—"TOP SOIL *to about one foot in depth, from the cut at the north end in section* 35, *on the Cincinnati Southern Railroad, Grant county. Collected by C. J. Norwood.*"

The dried soil is in friable clods of a dirty drab color, mottled with yellowish and ferruginous. The silicious residue, left after digestion of the soil in acids, all passed through the bolting-cloth, except many soft, whitish, rounded grains of partly decomposed silicates.

No. 2024—"SUBSOIL, *twenty-one inches thick, immediately below the top soil, from the same locality*," *&c.*

Dried subsoil in friable lumps; mottled with light grey and ferruginous of different tints. Silicious residue like that of the preceding.

No. 2025—"UNDER-CLAY, *two feet thick, lying just under the preceding. Same locality*," *&c., &c.*

A tough clay, mostly of an ochreous yellow color, mottled with grey-ferruginous, with some nearly black infiltrations of manganese oxide.

No. 2026—"UNDER-CLAY, *eight inches thick, just under the next preceding. Same locality*," *&c., &c.*

Dried clay not quite so tough as the next preceding; of rather a lighter yellowish color; mottled like that, but with less of the dark colored material. Silicious residue like that of the preceding.

No. 2027—"UNDER-CLAY, *six inches thick, just below the next preceding. Same locality*," *&c., &c.*

Dried clay in rather friable lumps, generally of a light yellowish brown color, mottled with light ochreous yellow. Silicious residue resembling that of the preceding.

No. 2028—"UNDER-CLAY, *twenty-six inches thick, just under the next preceding, lying on the limestone bed rock, and in some places seeming to replace the bed rock. Same locality as the preceding*," *&c., &c.*

Dried clay in rather tough clods, of a brownish yellow color, much mottled with dark brownish ferruginous. Silicious residue like that of the preceding.

COMPOSITION OF THESE SIX GRANT COUNTY SOILS, SUBSOILS, AND UNDER-CLAYS, DRIED AT 212° F.

	No. 2023.	No. 2024.	No. 2025.	No. 2026.	No. 2027.	No. 2028.
Alumina and iron and manganese oxides	7.225	9.852	16.827	14.492	21.124	23.100
Lime carbonate	.470	.390	1.640	2.315	4.305	3.640
Magnesia	.303	.447	.645	.609	.420	.223
Phosphoric acid	.185	.358	.358	.358	.361	.505
Potash	.738	.282	.213	.760	.210	.534
Soda	.....	.....	.337	.....	.308	.....
Water and organic matters lost on ignition	4.650	3.940	5.400	4.450	5.225	5.850
Sand and insoluble silicates	87.065	84.760	75.040	77.440	68.515	66.390
Total	100.636	100.029	100.460	100.424	100.268	100.242
Hygroscopic moisture	not est.	not est.	not est.	not est.	not est.	not est.
Potash in the insoluble silicates	1.812	1.673	2.103	2.851	2.700	2.865
Soda in the insoluble silicates	.722	.677	.433	.417	.378	.449
Character of the sample	Top soil.	Subsoil.	Under-clay.	Under-clay.	Under-clay.	Under-clay.

The general remarks on the first and second groups of these samples will apply equally well to these.

GRAYSON COUNTY.

No. 2029—"VIRGIN SOIL, *to the depth of about eight inches; from Grayson Springs, about four hundred yards west of the railroad. On the Leitchfield marl. Chester Group. Native forest growth, mostly white oak. Yield: of corn,* 25 *to* 40 *bushels; of wheat,* 12 *to* 15 *bushels; of tobacco,* 800 *to* 1,000 *pounds per acre. Good for clover and grasses. Collected by John H. Talbutt.*"

Dried soil, somewhat cloddy, of a light buff-grey color. The silicious residue all passed through the bolting-cloth.

No. 2030—"SUBSOIL *of the preceding, taken to the depth of three feet. Collected by John H. Talbutt.*"

The dried subsoil is of a dirty orange-grey color. The silicious residue, after digestion in acids, all passed through the bolting-cloth.

COMPOSITION OF THESE SOILS, DRIED AT 212° F.

	No. 2029.	No. 2030.
Organic and volatile matters	3.239	2.534
Alumina and iron and manganese oxides	3.096	4.781
Lime carbonate	.020	.045
Magnesia	.097	.061
Phosphoric acid	.144	.159
Sulphuric acid	not est.	not est.
Potash	.160	.100
Soda	.268	.102
Water, expelled at 380° F.	.506	.483
Sand and insoluble silicates	91.865	91.490
Total	99.395	99.775
Hygroscopic moisture	1.200	1.575
Potash in the insoluble silicates	0.927	1.198
Soda in the insoluble silicates	.262	.254
Character of the soil	Virgin soil.	Subsoil.

These soils, of average natural fertility, would require the application of lime or marl, with phosphatic and alkaline fertilizers, to enable them to maintain, indefinitely, a high degree of productiveness. Judicious rotation of crops, including the sufficient use of ameliorating clover or grass crops, to be grazed or plowed in, together with barn-yard manure, might keep them in good condition for quite a long period, without the application of any outside fertilizers, especially if the products were consumed upon the farm; but when these are exported a gradual deterioration must result in all soils, unless the essential mineral ingredients carried off in the products are in some manner restored.

GREENUP COUNTY.

COALS.

No. 2031—"COAL, *from Cane Creek Mines. New opening in the No. 3 Coal, near Hunnewell Furnace. Average sample No. 1; sent by Mr. H. W. Bates, Vice President of the Eastern Kentucky Railway Company.*"

A fine-looking coal, pitch black, breaking into thin laminæ, with no apparent pyrites, and some fibrous coal.

No. 2032—"COAL. *Average sample No. 2; taken from about one hundred yards from the place of the preceding sample. Same locality," &c., &c.*

Coal not quite so bright as the preceding sample. Some granular pyrites apparent between the laminæ.

No. 2033—"COAL. *Average sample No. 3; from the same locality as the two preceding; taken about one hundred yards distant from the others.*"

Resembles the last sample, but has no apparent granular pyrites. Some fibrous coal between the laminæ.

COMPOSITION OF THESE GREENUP COUNTY COALS, AIR-DRIED.

	No. 2031.	No. 2032.	No. 2033.
Specific gravity	1.345	1.344	1.383
Hygroscopic moisture	6.33	5.77	6.03
Volatile combustible matters	32.42	33.28	30.77
Coke	61.25	60.95	63.20
Total	100.00	100.00	100.00
Total volatile matters	38.75	39.05	36.80
Carbon in the coke	53 30	52.40	50.65
Ash	7.95	8.55	12.55
Total	100.00	100.00	100.00
Character of the coke	Dense spongy.	Dense spongy.	Dense spongy.
Color of the ash	Light lilac-grey.	Light lilac-grey.	Light lilac-grey.
Percentage of sulphur	1.277	0.900	1.458

Considerable local differences may be observed, in the relative proportions of ash and sulphur, in these samples from the same coal bed. They are all good coals of the variety "splint," or "semi-cannel," to which the celebrated "block coal" of Indiana belongs.

HARDIN COUNTY.

SOILS.

No. 2034—"VIRGIN SOIL, *from the farm of Gov. Jno. L. Helm, one mile north of Elizabethtown, Hardin county. Forest growth: beech, hickory, and oaks. Geological formation: St. Louis limestone. Collected by the Rev. H. Hertzer.*"

The dried soil is of a light yellowish-grey umber or dark drab color. The clods are friable. The coarse sieve removed from it a small quantity of ferruginous gravel. The silicious residue, after digestion in acids, all passed through the bolting-cloth, except a small quantity of fine quartz sand and a few particles of partly decomposed silicates.

No. 2035—"SURFACE SOIL, *which has been in cultivation for sixty years. From the same locality as the preceding soil. Average crops:* 35 *to* 45 *bushels of corn;* 12 *bushels of wheat, &c. This farm is considered a poor and worn out one. Decayed rock six to eight feet. Collected by Rev. H. Hertzer.*"

The dried soil is of a dirty-buff color; the clods quite firm. The coarse sieve separated from it a small quantity of ferruginous gravel. The silicious residue left on the bolting-cloth some fine quartz sand of various colors, and some grains of partly decomposed silicates.

No. 2036—"SUBSOIL *of the two preceding soils,*" *&c., &c.*

This dried subsoil is of a handsome deep orange buff color. Its clods are quite firm. The coarse sieve removed from it about five per cent. of rounded ferruginous gravel. The silicious residue resembled that of the two preceding samples.

COMPOSITION OF THESE THREE HARDIN COUNTY SOILS, DRIED AT 212° F.

	No. 2034.	No. 2035.	No. 2036.
Organic and volatile matters	4.495	2.575	2.350
Alumina and iron and manganese oxides	5.579	6.520	9.807
Lime carbonate	.340	.215	.140
Magnesia	.286	.227	.223
Phosphoric acid	.071	.070	.083
Sulphuric acid	not est.	not est.	not est.
Potash	.149	.119	.270
Soda	.037	.....	.....
Water, expelled at 380° F.	1.675	.950	.925
Sand and insoluble silicates	87.675	89.140	85.590
Total	100.307	99.816	99.388
Hygroscopic moisture	1.900	1.510	2.050
Potash in the insoluble silicates	1.250	1.037	0.848
Soda in the insoluble silicates	.432	.376	.286
Character of the soil	Virgin soil.	Old field soil.	Subsoil.

The greatest apparent deficiency in these soils is of the phosphoric acid; this is apparent even in the so-called virgin soil. There can be little doubt that the use of top-dressings of bone-dust, superphosphate, or guano would greatly increase their fertility. Although the old field soil shows evidence of the diminution of its essential mineral ingredients, as well as of its organic and volatile matters, *humus*, it is by no means to be considered "worn out." Judicious culture to restore its *humus*, by means of clover or other green crops, grazed and plowed in, with the use of phosphatic fertilizers, &c., would soon restore its fertility, if the land is properly drained.

No. 2037—"VIRGIN SOIL, *from the farm of J. W. Fowler, Colesburg, Hardin county. Forest growth: poplar, beech, sugar-tree, white and black oaks, hickory, &c. Geological formation: St. Louis Group. Blue calcareo-argillaceous shales. Decomposed rock three to four feet. Collected by the Rev. H. Hertzer.*"

This dried soil is of an umber-grey color. The coarse

sieve separated from it 4.31 per cent. of rounded fragments of silicio-ferruginous concretions or sandstone, with a little chert. The bolting-cloth removed from the silicious residue, after the usual digestion in acids, some small particles of partly decomposed silicates, and a portion of a very small encrinital stem.

No. 2038—"SURFACE SOIL, *thirty-four years in cultivation. From the same farm as the preceding soil, &c., &c. Average crops: of corn,* 35 *bushels; wheat,* 16 *bushels; oats,* 15 *to* 20 *bushels; of hay, one and a half tons per acre. Collected by Rev. H. Hertzer.*"

Dried soil of a lighter and more yellowish-grey color than the preceding. The coarse sieve removed from it nearly seven per cent. of rounded ferruginous sandstone gravel or concretions, with some cherty fragments. The silicious residue resembled that of the preceding soil.

No. 2039—"SUBSOIL *of the next preceding*," *&c., &c.*

The dried subsoil resembles the next preceding soil in color. The coarse sieve separated from it nearly nine per cent. of angular cherty fragments, with some silicified portions of encrinital stems and ferruginous gravel. The bolting-cloth removed from the silicious residue a few particles of partly decomposed silicates, one or two small clear quartz grains, and two fragments of minute silicified encrinital stems.

No. 2040—"VIRGIN SOIL, *from the farm of Van Buren Vandecraft, on Muldraugh's Hill, at Colesburg, Hardin county. Forest growth: poplar, beech, white oak, chestnut oak, sugar-tree. Geological formation: St. Louis Group. Decayed rock one to two feet. Collected by Rev. H. Hertzer.*"

Dried soil of a light buff-grey color. The coarse sieve removed from it 10.55 per cent. of angular cherty fragments, with some silicified encrinital stems and iron gravel. The bolting-cloth separated from the silicious residue a considerable proportion of partly decomposed silicate grains, some

resembling reddish felspar, with some minute silicified entrochi, and a few quartz grains.

No. 2041—"SURFACE SOIL, *fifty years in cultivation. From the same farm as the preceding soil. Average crop of corn, twenty bushels. Collected by Rev. H. Hertzer.*"

This dried soil is of a brownish salmon color. The coarse sieve separated from it only a small proportion of iron gravel, and a small rounded quartz pebble. The silicious residue resembled that of the preceding soil.

No. 2042—"SUBSOIL *of the next preceding soil,*" *&c., &c.*

The dried subsoil is of a handsome light brick red color. It all passed through the coarse sieve. The bolting-cloth removed from the silicious residue a considerable quantity of partly decomposed silicate grains, which were easily crushed under the finger, together with some blackish silicified portions of encrinital stems, &c.

COMPOSITION OF THESE SIX HARDIN COUNTY SOILS, DRIED AT 212° F.

	No. 2037.	No. 2038.	No. 2039.	No. 2040	No. 2041	No. 2042.
Organic and volatile matters	9.185	5.400	4.500	4.610	3.085	3.550
Alumina and iron and manganese oxides	8.705	8.228	8.347	6.033	6.597	11.254
Lime carbonate	1.350	.625	.465	.390	.290	.215
Magnesia	.124	.107	.142	.070	.040	.025
Phosphoric acid	.203	.172	.123	.102	.038	.061
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.595	.279	.175	.316	.035	.251
Soda	.011	.018	.077	.098	.025	.168
Water, expelled at 380° F.	2.715	2.075	2.000	1.625	1.150	1.550
Sand and insoluble silicates	77.905	83.090	84.440	86.355	88.940	83.490
Total	100.793	99.994	100.269	99.599	100.200	100.564
Hygroscopic moisture	2.885	2.315	2.265	1.815	1.335	2.575
Potash in the insoluble silicates	2.910	2.226	1.137	0.956	1.302	1.329
Soda in the insoluble silicates	1.166	.786	.733	.197	.443	.256
Character of the soil	Virgin soil	Old field soil.	Subsoil.	Virgin soil	Old field soil.	Subsoil.

It is interesting to notice in these soils the changes in composition brought about by long cultivation without the use of fertilizers. In the case of soils Nos. 2037 and 2038 the organic and volatile matters have been reduced from 9.185 to 5.400 per cent. by the thirty-four years of cultivation; the

lime carbonate from 1.350 to 0.625; the phosphoric acid from 0.203 to 0.172, and the potash from 0.595 to 0.279 per cent., while the percentage of sand and insoluble silicates is increased from 77.915 to 83.090 per cent. In the soils Nos. 2040 and 2041 we find that the sixty years' cropping of the latter have reduced some of its essential ingredients in still greater proportion. The organic matters, &c., are reduced from 4.610 per cent. to 3.085; the lime carbonate from 0.390 to 0.290; the phosphoric acid from 0.102 to 0.038 per cent., the potash from 0.316 to 0.035 per cent., and the sand and insoluble silicates are increased from 86.355 to 88.940 per cent.

The first set of soils was evidently naturally the richer; and the relative present productiveness of the soil of the two old fields corresponds nearly with their comparative richness or poverty, as shown by their chemical composition; for while the soil No. 2038 produces thirty-five bushels of corn per acre, soil No. 2041 yields only twenty bushels. This latter soil is greatly in want of phosphatic fertilizers, as well as those containing potash salts. There is no apparent reason why, by the proper use of such fertilizers, barn-yard manure, and a judicious system of rotation, with the cultivation of ameliorating green crops for grazing purposes and for plowing under, these soils may not be brought to and maintained in a condition of profitable productiveness.

HARRISON COUNTY.

No. 2043—*Some* LEAD ORE (*galena*), *mixed with zinc blende; in a gangue of barium sulphate, which included some angular fragments of embedded limestone; was brought to the laboratory by Mr. John R. Procter for analysis.*

This ore, reported to be argentiferous, is found in a vein of heavy spar, on the farm of the late Mr. Shawhan, one mile on the Lexington side of Cynthiana, on the Kentucky Central Railroad.

The lead sulphide was disseminated, in rather small proportion in the samples brought, throughout the gangue, and when reduced in the usual way, and analyzed, both by the wet way and by cupellation, it was not found to yield more than a trace of silver, in a lead button weighing more than eight grammes, obtained from thirty grammes of the galena: so that it evidently could not be profitably worked for this precious metal. The rather small proportion of lead ore seems also to preclude the profitable operation of this mine for the baser metal.

HOPKINS COUNTY.

Soils.

No. 2044—"VIRGIN SOIL; *surface soil to the depth of thirteen inches; from woods on the farm of Mr. Mills, near Nortonsville. Collected by John H. Talbutt.*" *Forest growth generally oaks. Slope of the surface west-south. Sample taken near the base of the hill, near a coal-shaft.*

The dried soil is of a dark umber-grey color. The coarse sieve removed from it a few small ferruginous concretions. The bolting-cloth separated from the silicious residue, remaining after the digestion in acids, 16.5 per cent. of the soil of fine white sand, composed of rounded quartz grains.

No. 2045—"SUBSOIL *of the preceding*," *&c., &c.*

The dried subsoil is in friable clods, of a brownish buff color. It all passed through the coarse sieve. The bolting-cloth removed from the silicious residue 10.50 per cent. of the soil of fine white sand, like that of the preceding.

COMPOSITION OF THESE HOPKINS COUNTY SOILS, DRIED AT 212° F.

	No. 2044.	No. 2045.
Organic and volatile matters	2.850	2.090
Alumina and iron and manganese oxides	4.952	6.883
Lime carbonate	.080	a trace.
Magnesia	.106	.181
Phosphoric acid	.083	.077
Sulphuric acid	not est.	not est.
Potash	.145	.307
Soda	.050	. . . . .
Water, expelled at 380° F.	.737	.660
Sand and insoluble silicates	90.540	89.700
Total	99.543	99.898
Hygroscopic moisture	1.085	1.285
Potash in the insoluble silicates	1.693	1.458
Soda in the insoluble silicates	.687	.697
Character of the soil	Virgin soil.	Subsoil.

These must be classed amongst the naturally weak soils, especially because of their small proportion of lime and phosphoric acid. These necessary ingredients can, however, be easily supplied in bone-dust, superphosphate, or guano, which, with a further supply of potash in some appropriate fertilizer, might make this soil quite productive, especially if proper means be used to increase the proportion of *humus*, organic and volatile matters, which are also in too small proportion in this soil.

JACKSON COUNTY.

No. 2046—"BLACK BAND IRON ORE. *On top of the thirty-four inch coal. Coyle's Bank. Big Hill, Jackson county. Collected by John R. Procter.*"

A dull, rusty-black ore; ferruginous on the weathered surfaces; shaly in structure. Some small reedy impressions between some of the irregular laminæ. Some granular pyrites apparent also.

COMPOSITION, DRIED AT 212° F.

Iron carbonate	70.168,	containing 33.875 iron.
Alumina and trace of manganese oxide	.430	
Lime carbonate	.930	
Magnesia carbonate	2.898	
Phosphoric acid	.345 =	.151 phosphorus.
Sulphur	.264	
Bituminous matters	18.540	
Silicious residue	6.230,	containing 4.960 silica.
Total	99.805	

If this ore is found in sufficient abundance, it may be smelted with advantage, for the production of iron of a low grade for ordinary purposes. Deducting the 18.54 per cent. of bituminous matters, which will act in the smelting furnace like so much fuel, the percentage of iron to the remainder is more than forty-one and a half.

JESSAMINE COUNTY.

No. 2047—"MINERAL WATER. *Salt sulphur water, from a well fifteen feet deep; in the Lower Silurian blue limestone; on the farm of James Llewellyn, on the Russell's Tavern turnpike, about two miles west of Nicholasville. Sample brought by Mr. B. M. Arnott.*" (Analyzed by my son, Alfred Meredith Peter, under my supervision.)

The water, brought to the laboratory in a stone-ware jug, corked and well sealed with wax, smelt strongly of hydrogen sulphide, but was somewhat turbid with a dark grey precipitate of iron sulphide, &c.

SUMMARY OF THE ANALYSIS MADE.

Carbonic acid gas, present but not estimated, because a part had escaped. Hydrogen sulphide gas, the quantity yet remaining was 0.015 gramme per litre, equal to 0.109 grain or 0.3 cubic inch per wine pint. Of course much more is present in the water at the well. The following named carbonates were found in the water, they being held in solution by the carbonic acid present, viz: lime, magnesia, iron and strontia carbonates, making a total weight of 0.276 gramme per litre; equal to 1.592 grains per wine pint of the water. (The litre equals 1000 grammes.) In the water, which had been boiled

and had deposited these carbonates, the following ingredients were found:

	In 1000 parts.	In a wine pint of the water.
Lime sulphate	0.016	0.117 of a grain.
Potash sulphate	not estimated.	
Magnesium chloride	.171	1.244 grain.
Sodium chloride	much; not est.	
Lithium chloride	a marked trace.	
Sodium bromide	considerable.	
Sodium sulphide	.052	.379 of a grain.
Silica	not estimated.	
Organic matters	not estimated.	
Total saline matters	4.882 per litre.	35.585 grains in the wine pint.

This is a very good salt sulphur water, resembling in its general composition the waters of the Blue Lick Springs and of Col. J. W. Hunt Reynolds' well, near Frankfort, as well as that of the salt sulphur well at the Olympian Springs, in Bath county.

The free hydrogen sulphide (sulphuretted hydrogen) and the sodium sulphide are nearly in the same proportions as in the Lower Blue Lick water; but the total saline matters are only about half as much. The difference may be mainly in the sodium chloride or common salt. These total saline matters, about five parts to the 1000 of the water, or about 55.5 grains to the wine pint, are nearly in the same amount as in the salt sulphur water of the Olympian Springs; but this water contains larger proportions of sodium sulphide and iron carbonate than that. It also is evidently somewhat stronger in hydrogen sulphide than the Olympian water.

There can be no doubt that this salt sulphur water may be beneficially employed, under judicious medical advice, in the treatment of many cases of disease for which sulphur waters are appropriate, especially as it is somewhat chalybeate when taken fresh from the well. Like all other sulphur waters, it soon decomposes when exposed freely to the air.

A more complete analysis would be necessary to determine the exact proportions of all its ingredients, requiring a visit to the well, for the testing of the recent water, and the use of a larger quantity of it at the laboratory.

LINCOLN COUNTY.

No. 2048—MINERAL WATER. "*Salt sulphur water, from a spring in the Black Devonian shale, at the Cincinnati Southern Railroad bridge over Green river; at about the level of the river; discovered by excavating for a 'borrow pit.' Sent for examination by R. M. Bishop, Esq. (now Governor of Ohio).*"

Although the water had been brought in a rather loosely stoppered bottle, it yet smelt and tasted strongly of compounds of sulphur. It was slightly turbid from the spontaneous precipitation of sulphur and iron sulphide, and was of a slightly yellowish tint, doubtless from the presence of sulphuretted sulphides, the result of partial decomposition of the hydrogen sulphide. Of course only a qualitative analysis could be made with the small amount of water supplied, under the circumstances.

SUMMARY.

The water was found to contain carbonic acid and hydrogen sulphide gases in considerable proportion. Held in solution by the carbonic acid were carbonates of lime, magnesia, and iron, and probably of strontia. It contains a large proportion of sodium chloride (common salt), with magnesium chloride and a trace of lithium chloride, besides a notable quantity of lime, magnesia, and potash sulphates, and sodium sulphide. It resembles, therefore, the Blue Lick water, but is much stronger in total saline matters and probably in sodium sulphide. The total saline matters of the Lower Blue Lick water amount to somewhat more than ten parts in the thousand, while those of this water equal about nineteen to the thousand of the water.

If this spring proves to be a constant one, the water deserves a complete quantitative analysis, and it could no doubt be made available as a remedial agent in many cases of disease.

LOGAN COUNTY.

Soils.

No. 2049—"VIRGIN SOIL, *from the bottom land of Wm. Morton, one mile north of Russellville, Logan county. Collected by Rev. H. Hertzer. Geological formation, St. Louis limestone. Forest growth: a natural canebrake, sycamore, elm, wild cherry, burr oak,*" *&c.*

The dried soil is mostly in friable clods, of a yellowish, light umber color. It contains no gravel. The silicious residue, left after digestion in acids, all passed through bolting-cloth, except a few particles of partly decomposed silicates and a small quantity of small rounded quartz grains, mostly colorless.

No. 2050—"SUBSOIL *to the bottom land above described,*" *&c.*

The dried subsoil is in clods, less friable than those of the above surface soil; of a light yellowish-brick color. It contains no gravel. The bolting-cloth separated from the silicious residue a considerable quantity of small rounded grains of milky and transparent quartz, also much of partly decomposed silicates in small, rounded, soft particles.

No. 2051—"SURFACE SOIL, *in cultivation thirty years; bottom land; from same farm as the two preceding. Average crops: of corn, 30 bushels; wheat, 10 bushels; oats, 10 to 15 bushels per acre. Collected by Rev. H. Hertzer.*"

Dried soil in pretty firm clods; of a dark umber-buff color, or light buff-umber. Clods mottled with light brick color. The coarse sieve removed from it a very few small ferruginous quartzy particles. The silicious residue contained rather more small quartz grains, and soft partly decomposed silicate particles, than the preceding.

No. 2052—"BLACK SOIL" (so-called); "*non-productive; all vegetables raised on it look sickly. Surface soil, from the Edgetown stock farm of H. B. Tully, Russellville. Collected by Rev. H. Hertzer.*"

The dried soil is in pretty firm clods, of a dark snuff-brown color. It contains no gravel. The silicious residue all passed through bolting-cloth, except a few small quartz grains, and a considerable proportion of soft rounded particles of partly decomposed silicates.

No. 2053—"SUBSOIL, *taken from a depth of six feet. From the same locality as the next preceding. Collected by Rev. H. Hertzer.*"

"It is the richest virgin soil from the decomposition of the St. Louis limestone, which rests underneath, partly decayed to six feet in depth. This subsoil, mixed with the lighter surface soil, makes very good bricks, and always enriches the surface soil when properly plowed up. It is preferred for the production of fine tobacco, characterized by broad silky leaves and small stems or midribs. Forest growth, cedar and black walnut."

This dried subsoil is of a bright brick-red color. It is somewhat cloddy. The coarse sieve removed from it some few angular particles of partly decomposed chert. The silicious residue all passed through the bolting-cloth, except a few small rounded grains of transparent quartz, and a considerable quantity of soft particles of partly decomposed silicates.

No. 2054—"SURFACE SOIL, *in cultivation for about thirty years. From the same locality as the preceding. Crops, generally of corn, the average yield of which is thirty bushels. Original growth: black walnut, elm, wild cherry, red and post oaks. Collected by Rev. H. Hertzer.*"

The dried soil is in friable clods of a light buff-umber color. Contains no gravel. Silicious residue like that of the next preceding.

No. 2055—"SUBSOIL *of the next preceding*," *&c., &c.*

Dried subsoil of a light brick color, in pretty firm clods. The coarse sieve separated from it a few particles of decomposing chert. The silicious residue is like that of the preceding.

COMPOSITION OF THESE LOGAN COUNTY SOILS, DRIED AT 212° F.

	No. 2049.	No. 2050.	No. 2051.	No. 2052	No. 2053	No. 2054.	No. 2055.
Organic and volatile matters	2.900	2.585	2.560	3.925	3.675	2.775	3.048
Alumina and iron and manganese oxides	3.247	7.095	5.297	8.315	11.811	4.812	9.158
Lime carbonate	.395	.210	.195	.640	.245	.180	.180
Magnesia	.115	.196	.160	.346	.227	.170	.214
Phosphoric acid	.093	.115	.093	.125	.109	.093	.077
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.132	.169	.121	.060	.212	.085	.326
Soda	.....	.....	.068	.....	.015	.....	.050
Water, expelled at 380° F.	.875	.765	.765	1.275	.950	.600	.775
Sand and insoluble silicates	92.350	88.755	90.935	85.035	82.365	91.090	86.275
Total	100.107	99.890	100.194	99.721	99.609	99.805	100.103
Hygroscopic moisture	1.435	2.385	1.550	2.675	3.800	1.250	2.525
Potash in the insoluble silicates	0.890	1.334	1.286	1.212	1.349	1.474	1.320
Soda in the insoluble silicates	.301	.357	.299	.353	.266	.532	.265
Character of the soil	Virgin soil	Subsoil.	Old field soil.	Black soil	Subsoil.	Old field soil.	Subsoil.

The group of soils Nos. 2049, 2050, and 2051 are naturally of average fertility, if they are sufficiently underdrained, with the exception that the virgin surface soil appears to be rather deficient in phosphoric acid and organic matters or *humus*. The use of phosphatic fertilizers, and the cultivation of green crops—of clover or grasses—to be grazed or plowed under, or of barn-yard manure, would no doubt greatly increase their productiveness. The surface could also be improved by a gradual mixture of the heavier subsoil with the surface soil during this process of amelioration.

The unproductiveness of the black soil seems to be partly due to a deficiency of potash. Possibly, however, the land is not sufficiently underdrained. If there is no want of drainage, the application of wood ashes, or other fertilizers containing potash, would undoubtedly restore productiveness, especially, as in other respects, this soil is not deficient in the essential elements. The red subsoil of the same locality, No.

2052, would no doubt answer the same purpose, because of its considerable proportion of potash, which may account for its favorable influence on the tobacco plant. Subsoils, however, should generally be *gradually* mixed with the surface soil, and accompanied by barn-yard manure, or some other organic fertilizer, to supply *humus*.

The influence of the thirty years' cultivation on the soil of the old fields is manifest in the reduction of the proportions of potash, phosphoric acid, lime, &c., and the increased proportion of the silicious material, as compared with the original soil. The continued cultivation of hoed or plowed crops, such as corn, for a long series of years, has a very deteriorating effect upon the soil, not only because the single crop generally draws inordinately on one kind of mineral matter, as, for example, the corn makes a great demand on the phosphoric acid of the soil, but also because the constantly exposed surface is greatly subject to the washing action of the atmospheric waters, which continually carry off its lighter and richer ingredients, while its *humus* is more than usually removed by the oxydating action of the air. A judicious rotation, in which green crops, covering the soil for a time, undisturbed by the plow, may protect the land from this washing and decomposing influence of the atmospheric agencies, while they, when grazed or plowed under, in whole or in part, may renew the *humus*, and bring the mineral ingredients of the soil into a soluble and available condition for the nourishment of intermediate grain crops, or even of tobacco crops, would conduce greatly to profitable farming, more especially if manures or fertilizers are applied to the green crops. The tobacco plant, which makes so heavy a demand on the soil for potash and lime, as well as phosphoric acid, undoubtedly requires a system of this kind for its continued or profitable cultivation.

LYON COUNTY.

IRON ORES.

No. 2056—"LIMONITE. *Labeled iron ore, from Hall's patch drift, Lyon county. Centre Furnace. Collected by P. N. Moore.*"

Mostly in dense, hard, brown, irregular laminæ, but containing a considerable proportion of red and yellow porous and soft ochreous material.

No. 2057—"LIMONITE. *Ore from Skillian Bank. Centre Furnace, Lyon county. Collected by P. N. Moore.*"

Mostly in dense, hard, dark-brown and blackish irregular layers, with but little of softer, reddish, brownish and yellow ochreous material.

Other Centre Furnace iron ores may be found under Trigg county.

COMPOSITION OF THESE LYON COUNTY IRON ORES, DRIED AT 212° F.

	No. 2056.	No. 2057.
Iron peroxide	66.192	68.162
Alumina } Manganese oxide }	1.393	1.763
Lime carbonate	a trace.	a trace.
Magnesia	a trace.	a trace.
Phosphoric acid	.185	.505
Sulphuric acid	a trace.	a trace.
Combined water	10.000	9.630
Silica and insoluble silicates	22.910	20.050
Total	100.680	100.110
Percentage of iron	46.320	47.703
Percentage of phosphorus	.079	.220
Percentage of sulphur	a trace.	a trace.
Percentage of silica	21.820	19.060

These are evidently very good iron ores, more especially No. 2056, which contains much the less of the injurious ingredient, phosphorus, and which, consequently, would yield quite a tough iron by judicious smelting.

MADISON COUNTY.

No. 2058—"COAL, *from Marshall Moran's Bank, Big Hill. Thickness of the bed about thirty-four inches. Average sample by John R. Procter.*"

A sub-conglomerate coal. A firm, pure-looking splint coal. Has some fibrous coal between the thin laminæ, but very little appearance of pyrites.

COMPOSITION, AIR-DRIED.

Hygroscopic moisture	3.57	Total volatile matters	40.10
Volatile combustible matters	36.53		
Light spongy coke	59.90	Carbon in the coke	55.77
		Light yellowish-grey ash	4.13
	100.00		100.00

The percentage of sulphur is only 0.749.

In volume IV of new series of these Reports, pages 109, 110, may be found the analyses of other samples of the coal from this layer, exhibiting considerable differences in the relative proportions of sulphur, &c., &c. No doubt the present sample is a better average sample than No. 1878, which exhibits so much larger quantity of sulphur.

No. 2059—MINERAL WATER. "*Sulphur water; from a well owned by Dr. J. Reed; bored seven hundred and fifty feet deep; begun in the Black Devonian shale, and probably passing into the Trenton limestone, near Paint Lick. Collected by John R. Procter.*"

This water, brought to the laboratory in a corked bottle, had of course lost most of its hydrogen sulphide by decomposition. It yet smelt of this compound, and was of a slightly yellowish tint, from the presence of a little sodium sulphide. It could not be quantitatively analyzed, but the evaporation of a portion of it showed that it contained a quantity of solid saline matters equal to 0.2892 to the 1000 parts, or about two grains to the wine pint. These were found, by testing, to consist of carbonates of lime, magnesia, iron, &c., held in solution by carbonic acid, and sulphates of magnesia, lime, and probably of potash, with small quantities of chloride and sulphide of sodium, &c. No doubt it is a good sulphur water, which deserves a complete analysis.

No. 2060—"RED BUD SOIL, *from the Covington farm, thirty-four miles east of Lexington, half a mile back of Elliston, Madison county. Collected by Mr. L. H. DeFriese.*"

"On the hill slope, nineteen degrees west, below the outcrop of the magnesian limestone and black Devonian shale. Depth of the surface soil, twelve to fifteen inches. Forest growth: red oak, burr oak, honey and black locusts, white and black walnuts, hickories, sycamore, maple, black, blue, and white ash, &c. Yield: thirty to fifty bushels of corn, eight to fifteen of wheat, fifteen to twenty of oats. No hemp raised, and but little rye."

The dried soil is of a brown-umber color. The coarse sieve separated from it 1.14 per cent. of ferruginous and cherty particles. The bolting-cloth removed, from its silicious residue, a considerable portion of fine rounded quartzose grains, mostly transparent, with a few dark colored particles of undecomposed silicates.

COMPOSITION, DRIED AT 212° F.

Organic and volatile matters	5.825
Alumina and iron and manganese oxides	10.434
Lime carbonate	.615
Magnesia	.043
Phosphoric acid	.301
Potash	.379
Soda	.094
Water, expelled at 380° F.	2.415
Sand and insoluble silicates	78.965
Total	99.071
Hygroscopic moisture	3.165
Potash in the insoluble silicates	1.537
Soda in the insoluble silicates	.300

On reference to volume IV, first series of Reports of the Kentucky Geological Survey, page 215, it will be seen that this rich soil has undergone some deterioration since the analyses there reported were made, about eighteen years ago. According to the description of soil No. 1128, given

on page 214, it was collected from the same place, or nearly so, as the soil above described. Local differences, however, may exist, making the comparison imperfect.

M'CRACKEN COUNTY.

No. 2061—"SURFACE SOIL, *to the depth of eight inches. From the farm of L. M. Flournoy, three miles from Paducah. Tertiary formation, &c. Forest growth: mostly oaks of various species, with some hickories, &c. The corn crop averages twenty-five to forty bushels per acre. It is good tobacco soil, and considered average soil of the county. Some sandstone in the ravines, and indications of iron ore within half a mile. Collected by John H. Talbutt.*"

The dried soil is of a light greyish-buff color; friable. The coarse sieve removed from it only a few small fragments of decomposing chert. The bolting-cloth separated, from its silicious residue, only a few small particles of partly decomposed silicates.

No. 2062—"SUBSOIL *of the next preceding*," *&c.*

The dried subsoil is of a darker buff color, and the clods are more adhesive than those of the above; they are mottled with greyish and darker buff. It all passed through the coarse sieve. Silicious residue like that of the preceding.

No. 2063—"UNDER-CLAY *of the two preceding soils, &c. (Sand beneath this)*," *&c.*

The dried under-clay resembles the subsoil, but the clods are more firm. All passed through the coarse sieve. The bolting-cloth removed from the silicious residue a large proportion of particles of partly decomposed silicates.

COMPOSITION OF THESE McCRACKEN COUNTY SOILS, DRIED AT 212° F.

	No. 2061.	No. 2062.	No. 2063.
Organic and volatile matters	2.050	2.650	2.675
Alumina and iron and manganese oxides	5.497	12.300	10.834
Lime carbonate	.115	.190	.190
Magnesia	.268	.521	.649
Phosphoric acid	.093	.115	.061
Potash	.167	.284	.643
Soda	.171	. . . . .	.087
Water, expelled at 380° F.	1.000	1.000	1.000
Sand and insoluble silicates	90.940	82.490	83.865
Total	100.301	99.550	100.004
Hygroscopic moisture	1.425	4.000	3.425
Potash in the insoluble silicates	1.700	1.605	1.427
Soda in the insoluble silicates	.598	.911	.668
Character of the soil	Surface soil	Subsoil.	Under-clay

These soils, of average natural fertility, could no doubt be greatly improved in productiveness by the use of top-dressings of phosphatic fertilizers, such as bone-dust, superphosphate, or guano. The subsoil is richer than the surface, especially in potash, and might be gradually plowed up and mixed with it in cultivation with advantage. The manurial products of the barn-yard and stables, both solid and liquid, should be carefully husbanded and regularly used upon the soil. There is no reason why a very high degree of productiveness may not be maintained on this soil by a judicious system of farming, in the proper use of fertilizers, and a due rotation of crops, if it is well drained.

MEADE COUNTY.

Soils.

No. 2064—"Virgin Surface Soil, *from the land of Mr. McCarty, Muldraugh, Meade county. Sample taken twenty yards from the railroad, half a mile from the station. Underlying rock, buff and blue sandstone of the Waverly Group. Collected by John H. Talbutt.*"

"Forest growth, white oaks, some trees five feet in diam-

eter; poplar (liriodendron), some eight feet in diameter; large chestnut, beech, red oak, shellbark hickory, some sugar-tree, &c. Average corn crop, twenty to thirty bushels."

Dried soil of a brownish umber-grey color. Clods somewhat adhesive. It all passed through the coarse sieve, except some small angular fragments of weathered chert, and a little shot iron ore. The bolting-cloth removed, from the silicious residue, some rounded grains of quartz and of dark colored silicates.

No. 2065—"SUBSOIL *to the preceding*," *&c., &c.*

The dried subsoil is cloddy. Its general color is reddish ferruginous, mottled with lighter colored and grey. It contains fragments of weathered chert. The clods are quite firm. The silicious residue contains a small quantity of small rounded quartz grains.

No. 2066—"UNDER-CLAY *below the two preceding*," *&c., &c.*

Clods quite adhesive. Generally of a handsome buff color, mottled and infiltrated with red ferruginous. It contains a considerable proportion of fragments of weathered chert.

COMPOSITION OF THESE MEADE COUNTY SOILS, DRIED AT 212° F.

	No. 2064.	No. 2065.	No. 2066.
Organic and volatile matters	3.565	5.665	3.600
Alumina and iron and manganese oxides	5.091	15.741	11.604
Lime carbonate	.095	.070	.045
Magnesia	.133	.242	.538
Phosphoric acid	.109	.140	.156
Potash	.156	.425	1.082
Soda	. . .	. . .	. . .
Water, expelled at 380° F.	1.000	1.335	.650
Sand and insoluble silicates	89.725	75.825	82.125
Total	99.874	99.443	99.800
Hygroscopic moisture	1.600	4.265	2.950
Potash in the insoluble silicates	1.297	1.540	2.259
Soda in the insoluble silicates	.471	.304	.150
Character of the soil	Virgin surface soil.	Subsoil.	Under-clay

These soils would be greatly improved by top-dressings of lime or calcareous marl in considerable quantity. The subsoil and under-clay are quite rich in potash, and might be gradually mixed with the upper soil during cultivation. The small average crop of corn is probably due, in part, to the paucity of lime in these soils.

MERCER COUNTY.

No. 2067—"LIMESTONE, *containing green sand or glauconite. Sent by Mr. H. L. Tabler, of Harrodsburg, who says there is a bed of it two feet thick near that place.*"

A dull, grey, fine-granular limestone, containing a large proportion of small, rounded, bluish-green grains of what seems to be green sand or glauconite, together with a considerable proportion of bright, minute, cubical iron pyrites.

Some of the limestone, coarsely powdered, was digested in a warm solution of ammonium nitrate, afterwards in weak chlorhydric acid, to remove the calcium carbonate. The residue was then ignited to remove sulphur from the iron bi-sulphide, after which the iron proto-sulphide was separated by means of a magnet.

The remaining green particles were fused with mixed alkalies, and analyzed, with the following result, viz:

Silica	58.120
Iron and manganese oxides and alumina	32.398
Lime	.784
Magnesia	.807
Phosphoric acid	.102
Alkalies and loss	7.789
Total	100.000

The proportion of the green particles in the limestone was not ascertained, but the whole material fused readily before the blow-pipe, with intumescence, into a dark colored slag. Some of the original limestone was also examined as to its alkaline ingredients, and was found to yield: of potash, 3.372

per cent.; of soda, .319 per cent.; so that there is little doubt that the green particles are glauconite.

As to the probable economic uses of this green limestone layer, little can be said. Some of it was calcined, in a powdered state, and tested as to its availability in the manufacture of hydraulic cement, but it was found not to harden in water. Possibly calcination with more lime might develop this property. It is possible, also, that careful calcination alone, or with more lime, might make it available as an alkaline fertilizer.

NICHOLAS COUNTY.

No. 2068—"MINERAL WATER. *Re-examination of the salt sulphur water of the celebrated Lower Blue Lick Spring.*"

About twenty-seven years have passed since the present writer submitted this water to a quantitative chemical analysis, the results of which, published at the time, are reproduced in volume III of the first series of Reports of the Geological Survey of Kentucky (see pages 361 to 368). Desiring to ascertain whether any material change had occurred during this lapse of time, in the general composition of this water, and also to search for and determine some of its minuter ingredients, not at that time sought for, a new examination was made of it; Messrs. Hamilton, Gray & Co., of Maysville, having kindly placed at the disposal of the writer a barrel of the recent water.

The comparative results of the two analyses, made twenty-seven years apart, show a remarkable resemblance, proving that this celebrated water has not been sensibly weakened or altered in composition during this period, as follows:

COMPOSITION IN 1000 MEASURED PARTS OF THE WATER.

	Analysis 1850.	Analysis 1877.
Specific gravity	1.007	1.0072
Sulphuretted hydrogen gas	0.3947	not determ'd.
Free carbonic acid gas	.3547	not determ'd.
Lime carbonate	0.3850	0.3184
Magnesia carbonate	.0022	.0211
Alumina, phosphate of lime and iron carbonate	.0058	.0038
Sodium chloride	8.3473	8.3571
Potassium chloride	.0227	.1860
Magnesium chloride	.5272	.4864
Magnesium bromide	.0039	.0195
Magnesium iodide	.0007	.0003
Lime sulphate	.5533	.5508
Potash sulphate	.1519	. . . . .
Calcium chloride	. . . . .	.0606
Lithium chloride	. . . . .	.0060
Sodium sulphide	. . . . .	.0307
Soda carbonate	. . . . .	.0140
Soda bi-borate	. . . . .	.0298
Baryta sulphate	. . . . .	.0002
Strontia sulphate	. . . . .	.0011
Silicic acid	.0179	.0149
Organic acids and loss	.2821	.4573
Total saline matters in 1000 parts	10.3000	10.5580

The minuter ingredients discovered in this water, in this more complete analysis, are compounds of lithium, barium, strontium, and boron, as well as small quantities of sodium sulphide and soda carbonate.

The two latter compounds, with the soda bi-borate, give a slightly alkaline reaction to the water, and the sodium sulphide gives it greater durability as a *sulphur* water than the hydrogen sulphide alone does. The notable proportion of soda bi-borate doubtless adds to its medicinal virtues. As for the compounds of barium and strontium, they are in so small proportions, and probably in the nearly inert form of sulphates, that it is doubtful whether any influence can be attributed to them. It has not been fully determined whether the compounds of lithium, in such small quantities as they are usually found in mineral waters, exert any curative influence whatever; but doubtless these, as well as the other minute ingredients,

are not without effect in this complex solution. Practical experience alone in the use of such waters must determine these questions.

OHIO COUNTY.

Iron Ores.

No. 2069—"Clay Ironstone, *from Wm. Downs' 'Iron Mountain.' Rough creek, above Hartford, near the base of the coal measures. Second bed, three to six inches thick. Collected by C. J. Norwood.*"

A compact, fine granular, dark-grey ore. Not adhering to the tongue. Exterior thinly incrusted with limonite.

No. 2070—"Clay Ironstone. *From the same locality. Third ore bed. Composed of two layers, with a thin clay parting, measuring from three to four and two to four inches, severally. Collected by C. J. Norwood.*"

Resembles the preceding.

No. 2071—"Clay Ironstone. *From the same locality. Fourth ore bed. Six inches thick. Collected by C. J. Norwood.*"

Resembles the preceding, but has more exterior limonite.

COMPOSITION OF THESE CLAY IRONSTONES, DRIED AT 212° F.

	No. 2069.	No. 2070.	No. 2071.
Iron carbonate	60.012	69.117	48.211
Iron peroxide	not est.	not est.	9.227
Alumina and manganese oxide	11.451	7.437	7.307
Lime carbonate	4.430	4.780	5.880
Magnesia carbonate	5.395	4.639	4.298
Phosphoric acid	.377	.786	1.805
Sulphuric acid	trace.	.084	.030
Silica and insoluble silicates	17.280	11.480	19.850
Water and organic matters	1.055	1.677	3.392
Total	100.000	100.000	100.000
Percentage of iron	29.557	32.294	29.484
Percentage of phosphorus	.146	.343	.475
Percentage of sulphur	trace.	.034	.012
Percentage of silica	13.860	6.860	17.460

While these claystone ores could not be made to compete with limonite ores of favorable composition in the production of the best tough iron, they may yet be made available, in the

vicinity of abundant cheap fuel and limestone, for the production of cheap iron for many uses. Of course the preliminary of roasting these ores will be necessary.

No. 2072—"LIMESTONE, *under Coal A, Ben's Lick Hill. On the hill above Brown's Coal Bank, three miles southwest from Hartford, Ohio county. Collected by C. J. Norwood.*"

A compact or fine granular fossiliferous limestone, of a dirty grey color, presenting a somewhat brecciated appearance in parts, with ferruginous stains in the veins.

No. 2073—"LIMESTONE, *ferruginous, below Coal D, on Rough creek, mouth of Brush creek, three miles below Hartford. Collected by C. J. Norwood.*" (*Will it serve for cement?*)

A compact or very fine-grained limestone. Interior generally dark slate-grey; exterior, and in the veins, ochreous. Somewhat brecciated in parts.

Some of this rock, in the state of powder, was heated to redness in an open crucible, for an hour and a half, then mixed into a stiff paste with cold water—a portion with sand, and a part without sand; the wet lumps were exposed to a moist atmosphere for a day, and then immersed in water. The lump containing no sand *hardened completely;* that with the sand did not become so hard.

COMPOSITION OF THESE OHIO COUNTY LIMESTONES. DRIED AT 212° F.

	No. 2072.	No. 2073.
Lime carbonate	90.780	41.680
Magnesia carbonate	1.501	22.748
Alumina and iron and manganese oxides	1.189	8.640
Phosphoric acid	.371	.153
Sulphuric acid	not est.	not est.
Potash	.327	1.253
Soda	.100	.323
Silicious residue	4.160	24.060
Moisture and loss	1.572	1.143
Total	100.000	100.000
Percentage of lime	50.837	23.341

While the first sample will yield very good lime for ordinary purposes, the second may make very good hydraulic cement

by careful calcination. It does not require as much sand as other hydraulic limestones which contain a smaller proportion of silicious matters.

CLAYS OF OHIO COUNTY.

No. 2074—"INDURATED CLAY, *below Coal F, mouth of Brush Run, on Rough creek. Collected by C. J. Norwood.*"

A dark-grey shaly-clay, with impressions and remains of reed-like leaves, and some ferruginous stains.

No. 2075—"CLAY, *from near Elm Lick, on R. B. Thompson's land. Coal measures. A good deal used in Louisville. Collected by C. J. Norwood.*"

An irregularly laminated clay, mottled with grey of various tints, and ferruginous infiltrations. Has some imperfect vegetable impressions, and minute glimmering specks of mica.

No. 2076—"CLAY, *from Bald Knob Church, Caney precinct, on the Pinchico road, about two feet below a coal bed. Collected by C. J. Norwood.*"

In friable lumps, showing imperfect and irregular stratification. Of a light bluish-grey color, with infiltrations of ochreous and ferruginous, occasionally nearly black, especially in the cracks and along the course of rootlets which have penetrated it. Before the blow-pipe it appears to be quite refractory, not fusing, but softening and shrinking somewhat into a hard, porcelain-like, nearly white mass. When not so intensely heated it burns of a light salmon color.

COMPOSITION OF THESE OHIO COUNTY CLAYS, DRIED AT 212° F.

	No. 2074.	No. 2075.	No. 2076.
Silica	69.260	70.860	62.760
Alumina	16.640	19.240	26.420
Iron oxide	4.520	3.120	1.580
Lime	a trace.	a trace.	.325
Magnesia	.893	.425	a trace.
Phosphoric acid	a trace.	a trace.	not est.
Potash	3.102	2.351	.916
Soda	.210	.253	.268
Water and loss	5.375	3.751	7.731
Total	100.000	100.000	100.000

No. 2076 contains 5.3 per cent. of fine transparent colorless sand grains. This seems to be a very good fire-clay.

OLDHAM COUNTY.

SOILS.

No. 2077—"VIRGIN SOIL, *from the surface, and to the depth of thirteen inches. From the farm of Dr. Coy Kaye, Pewee Valley. Upper Silurian formation. Forest growth: beech, oak, poplar, black gum, &c. Soil better than usual in this locality. Collected by John H. Talbutt.*"

Dried soil, of a brownish-grey color; friable; contains no gravel. Its silicious residue all passed through the bolting-cloth.

No. 2078—"SUBSOIL *of the preceding*," *&c., &c.*

Dried subsoil of a bright brick color, somewhat cloddy. Contains no gravel. The bolting-cloth separated, from the silicious residue, a very few small rounded quartz grains.

No. 2079—"SURFACE SOIL, *from white oak land, Pewee Valley. Collected by A. W. Kaye.*" *Uncultivated.*

The dried soil is in friable clods, of a dark umber-grey color. Contains no gravel. The silicious residue, left after digestion in acids, all passed through the bolting-cloth, except a few small milky quartz grains.

No. 2080—"SUBSOIL *to the preceding*," *&c., &c.*

The dried subsoil is generally of a dark, orange-buff color, mottled with light grey and ferruginous. It contains some nearly black concretions and infiltrations. The clods are somewhat firm. It contains a few small fragments of weathered chert. The bolting-cloth separated, from the silicious residue, some hard particles—reddish and white—of undecomposed silicates, resembling felspar.

COMPOSITION OF THESE OLDHAM COUNTY SOILS, DRIED AT 212° F.

	No. 2077.	No. 2078.	No. 2079.	No. 2080.
Organic and volatile matters	4.612	3.016	4.215	3.250
Alumina and iron and manganese oxides	4.449	8.882	5.010	9.008
Lime carbonate	.145	.195	.245	.220
Magnesia	.313	.304	.250	.178
Phosphoric acid	.141	.098	.125	.077
Sulphuric acid	not est.	not est.	not est.	not est.
Potash	.388	.521	.138	.349
Soda	.055	.117	.035	.330
Water, expelled at 380° F.	.713	.607	1.535	1.150
Sand and insoluble silicates	88.665	86.465	88.240	84.825
Total	99.481	100.205	99.793	99.387
Hygroscopic moisture	1.900	2.875	1.850	3.300
Potash in the insoluble silicates	1.281	1.109	1.428	1.088
Soda in the insoluble silicates	.381	.444	.663	.022
Character of the soil	Virgin soil.	Subsoil.	Surface soil	Subsoil.

Soils Nos. 2077, 2078, and 2080 are exceptionally rich in potash; the other contains an average amount. The subsoils in both samples are somewhat deficient in phosphoric acid. These may be classed as good rich soils, but their productiveness might be improved and maintained by increasing their proportion of *humus* in a rotation of crops, and by the use of phosphatic fertilizers. It is also probable that plaster of Paris on the clover crop may be beneficial on soils Nos. 2077 and 2078.

TRIGG COUNTY.

No. 2081—"LIMONITE *iron ore. From a bank one mile south of Centre Furnace. Average sample, by P. N. Moore.*"

This ore is mostly in dense, hard, irregular hematitic layers, dark brown and nearly black, with but little of the softer ochreous ore.

COMPOSITION, DRIED AT 212° F.

Iron peroxide	71.708	= 50.195 per cent. of iron.
Alumina and manganese oxide	.945	
Lime carbonate	trace.	
Magnesia	trace.	
Phosphoric acid	.217	= .095 per cent. of phosphorus.
Sulphuric acid	trace.	
Combined water	9.630	
Silicious residue	17 280	= 16.960 per cent. of silica.
Total	99.780	

This is quite a rich and pure ore, which would doubtless produce a very tough iron, provided the fuel and flux employed in the smelting process are free from sulphur and phosphorus.

PIG IRONS OF CENTRE AND TRIGG FURNACES, TRIGG COUNTY.

No. 2082—"PIG IRON No. 1. *Foundry iron. From Centre Furnace. Collected by P. N. Moore.*"

A moderately coarse-grained grey iron. Yields readily to the file. Large fragments of it break readily, but the smaller ones extend considerably under the hammer.

No. 2083—"PIG IRON No. 2. *Foundry iron. Centre Furnace. Collected by P. N. Moore.*"

Somewhat finer grained than the preceding, especially on the outer surfaces, and a little lighter colored. Yields readily to the file, and extends considerably under the hammer.

No. 2084—"PIG IRON No. 3. *Mill iron. Centre Furnace,*" *&c., &c.*

Lighter colored, finer grained, and more brittle than the preceding.

No. 2085—"PIG IRON. *Mill iron. From Trigg Furnace,*" *&c., &c.*

Quite a fine grained grey iron. The small fragments extend considerable under the hammer. Yields to the file.

No. 2086—"PIG IRON. *Silver Grey. From Trigg Furnace, &c. Collected by P. N. Moore,*" as were also the above described.

Hard; easily splintered on the edges. The small fragments extend very little, before breaking, under the hammer.

COMPOSITION OF THESE CENTRE AND TRIGG FURNACE PIG IRONS.

	No. 2082.	No. 2083.	No. 2084.	No. 2085.	No. 2086.
Specific gravity	6.872	7.027	7.183	6.934	6.864
Iron	92.349	92.953	93.946	91.173	89.576
Graphite	3.380	3.140	2.860	3.400	1.000
Combined carbon	.....	1.010	1.060	.....	1.380
Aluminum and manganese	not est.	not est.	not est.	not est.	not est.
Silicon	3.794	2.641	1.932	4.592	6.637
Slag	.660	.100	.360	1.160	1.560
Phosphorus	.318	.318	.276	.262	.221
Sulphur	.067	.074	.104	.094	.121
Total	100.568	100.236	100.538	100.681	100.495
Total carbon	3.380	4.150	3.920	3.400	2.380

These are all good samples of pig iron. The mill iron does not contain enough phosphorus to prevent it from producing good tough bar iron by judicious puddling.

WARREN COUNTY.

No. 2087—"MINERAL WATER. *Sulphur water. From a bored well two hundred and thirty feet deep. Smith's Grove, one hundred miles from Louisville, on the Louisville and Nashville Railroad. Sent by Junius Wooten, M. D.*"

The water was brought in tightly corked bottles, but when it arrived at the laboratory the hydrogen sulphide had all been decomposed; it was slightly opalescent, probably from the consequent precipitation of sulphur. It is slightly alkaline.

As there was an insufficient quantity of the water, a complete analysis could not be made; but from the preliminary examination of it, the following provisional summary of its composition is given: hydrogen sulphide gas, quantity not estimated; carbonic acid gas, not estimated.

SALINE CONTENTS.

Lime carbonate	0.1445	Dissolved by the carbonic acid.
Magnesia carbonate	.0177	
Strontia carbonate	not est.	
Lime sulphate	.0998	
Magnesia sulphate	.2856	
Potash sulphate	.0041	
Soda sulphate	.0213	
Sodium chloride	.0520	
Lithium chloride	not est.	
Soda carbonate	.0381	
Silica	.0022	
Ingredients undetermined and loss	.2547	
Saline ingredients in 1000 parts	0.7200	

It is desirable that a more thorough analysis should be made of this water, which seems to be a good saline sulphur water, which may be made serviceable in the treatment of various ailments.

This well is within six miles of the Chalybeate and Chameleon Springs of Edmonson county, and its use is said by Dr. Wooten to be beneficial in dyspepsia and indigestion, &c. The spectroscope showed in it traces of lithium and strontium compounds.

APPENDIX.

TEXAS CRETACEOUS SOILS.

With a view to comparison with our Kentucky soils, some of the black soils from the cretaceous formation of Texas were analyzed.

No. 2088—"BLACK SANDY SOIL. *From three miles northwest of Sherman, Grayson county, Texas. Prairie soil, in cultivation. Collected by Mr. Jesse H. Talbutt.*"

A dark, mouse-colored sandy soil, containing many fragments of roots, &c. The silicious residue, after digestion in acids, all passed through the bolting-cloth, except a small quantity of colorless, transparent, rounded grains of quartz.

No. 2089—"SOIL. *From 'black waxy' land, half a mile east of Sherman, farm of H. H. Allen. Prairie land. Collected by Mr. Jesse H. Talbutt.*"

Quite an adhesive soil; in clods; of a greyish-black color. The silicious residue all passed through the bolting-cloth.

No. 2090—"SOIL. *From 'black waxy' land, H. M. Stone's, two miles west of Playno, Collins county, Texas. Prairie land, in corn. Collected by Mr. Jesse H. Talbutt.*"

Not quite so black as the preceding; not in clods; friable. Effervesces strongly with acids.

COMPOSITION OF THESE TEXAS SOILS, DRIED AT 212° F.

	No. 2088.	No. 2089.	No. 2090.
Organic and volatile matters	4.977	7.233	7.097
Alumina and iron and manganese oxides	2.616	8.157	11.447
Lime carbonate	.880	1.745	17.085
Magnesia	.169	.223	.231
Phosphoric acid	.124	.083	.143
Sulphuric acid	not est.	not est.	not est.
Potash	.078	.211	.497
Soda	.052	.051	. . . . .
Water, expelled at 380° F.	.799	1.391	1.660
Sand and insoluble silicates	89.690	80.690	61.840
Total	99.385	99.784	100.000
Hygroscopic moisture	3.075	0.665	0.850
Potash in the insoluble silicates	0.670	0.764	0.443
Soda in the insoluble silicates	.322	.159	.307
Character of the soil	Bl'k sandy.	Bl'k waxy.	Bl'k waxy.

These Texas prairie soils differ from most of our Kentucky soils in their smaller proportion of alkalies in the silicious residue; they also present a larger quantity of carbonate of lime, which is very large in soil No. 2090, and which helps to give the waxy character to the land. The so-called black sandy soil is quite deficient in potash, and would not prove durably productive without the continued use of fertilizers. The richest of them all is No. 2090. The rock substratum to these

soils is an indurated chalk, the imperfect analysis of which is given below.

No. 2091—"INDURATED CHALK ROCK. *From near Sherman, Texas. Collected by Mr. Jesse H. Talbutt.*"

A whitish, somewhat friable rock, stained irregularly with light ferruginous. Adheres firmly to the tongue.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	86.270
Magnesia carbonate	trace.
Alumina and iron and manganese oxides	2.980
Silicious residue	10.276
Alkalies, phosphoric acid, &c.	not det'd.
Total	99.526

No doubt the action of the large quantity of carbonate of lime, derived from this soft substratum, in gradually decomposing the silicates of the soil, is the cause of the rather small proportion of the alkalies in the insoluble silicates of the silicious residue.

CHEMICAL EXAMINATION OF THE ASHES OF THE HUNGARIAN GRASS (PANICUM GERMANICUM) AND GERMAN MILLET (PANICUM ——).

No. 2092—"HUNGARIAN GRASS (*black-headed*), *taken roots and all, the leaves being nearly all green, and the seeds in the soft or doughy state. Plants about three feet high, in the condition in which they are generally mown for hay.*"

The field on which they were grown had been in winter rye, which had been all grazed down by cattle, and the cattle had been fed with corn fodder on the ground during the winter. The grass had been sown about the first of June, 1875, and it was mown August 9th to 13th. Rich blue grass soil. Farm of R. Peter, Newtown Turnpike.

The quantity taken for analysis; weighing 524 grammes in the green state, after washing it in the evening and subsequent drying through the night; grew on less than a square foot of surface, and when thoroughly air-dried weighed 182 grammes, or 34.751 per cent. of the green plants.

No. 2093—"HUNGARIAN GRASS, *same variety as the preceding. From the adjoining farm of Mr. C. M. Keiser; gathered June 27th*, 1876.

Plants three to three and a half feet high. The heads just forming.

No. 2094—"GERMAN MILLET. *From a field of ten acres, just outside the city limits of Lexington, on the Newtown Turnpike; property of Mr. J. K. Drake.*"

This field has been fully seventy-six years in cultivation, mostly in corn and garden stuffs, with occasional small grain. Five years ago it was manured with seventy-five cart-loads of stable manure to the acre, and sowed in clover, which was allowed to remain until last year, when the ground was put in hemp, which was rotted on the same surface. The clover was mowed only one year, and in the other years very few cattle were grazed on it; so that most of it rotted on the ground. The German millet sown this year, 1875–'6, gave seventeen stacks, estimated at two tons each, of hay, equal to more than three tons to the acre. The grass grew nearly five feet high, and was coarse and hard in the stalks. The sample, gathered about the time of mowing it, August 28th, had its heads heavy with ripe seed; lower leaves dead.

In the green state it weighed two hundred and four grammes. After two months air-drying in the laboratory it weighed ninety-six and a half grammes, of which there were thirty-seven grammes of seed. The stalks and leaves were incinerated separately from the seeds.

No. 2095—"THE SEEDS *of the above described sample.*"

For comparison, the analysis of the ash of the buckwheat and clover plants are appended (the latter in Table II), copied from a memoir by the writer (in volume II, pages 157, 158 (lower paging), Kentucky Geological Reports, second series).

TABLE I. COMPOSITION, CALCULATED IN 100 PARTS OF THE ASH. CARBONIC ACID EXCLUDED.

	No. 2092.	No. 2093.	No. 2094.	No. 2095.	Vol. 2, p. 158,* second series, Geological Reports.
	Hungarian grass.	Hungarian grass.	German millet, stalks and leaves.	German millet, seeds.	Buckwheat plants in flower
Lime	0.957	0.937	11.330	7.711	33.434
Magnesia	.490	1.260	3.237	6.916	10.518
Alumina and iron and manganese oxides	2.090	3.378	3.624	1.690	not est.
Potash	21.724	47.707	32.609	24.265	32.900
Soda	.167	.135	.474	. . . . .	1.266
Phosphoric acid	9.170	10.033	10.776	16.994	16.824
Sulphuric acid	.811	2.008	.717	.578	1.378
Chlorine	.097	2.620	.243	.319	.431
Silica, soluble	1.914	.254	37.070	40.387	3.249
Silica, insoluble	61.835	31.609			. . . . .
Total	99.265	99.941	100.080	98.860	100.000
Percentage of ash to dried plants	8.067	6.461	4.968	2.505	8.762
Percentage of ash to green plants	2.802	not est.	2.350	. . . . .	1.577
Percentage of dried to green plants	34.751	not est.	47.300	. . . . .	18.000

*The lower paging.

TABLE II. COMPOSITION OF THE ASH OF THESE PLANTS, SEEDS, &c. CARBONIC ACID EXCLUDED. CALCULATED IN 100 PARTS OF THE DRIED PLANTS, &c.

	No. 2092.	No. 2093.	No. 2094.	No. 2095.	Vol. 2, p. 158,* second series, Ky. Geological Reports.	Vol. 2, p. 157,* second series, Ky. Geological Reports.
	Hungarian grass.	Hungarian grass.	German millet, stalks and leaves.	German millet, seeds.	Buckwheat plants in flower	Clover plants.
Lime	0.076	0.060	0.562	0.193	2.929	2.30
Magnesia	.040	.082	.161	.173	.922	.89
Alumina, iron and manganese oxides	.168	.218	.180	.042	. . . . .	. . . . .
Potash	1.752	3.082	1.619	.6c8	2.883	2.30
Soda	.013	.009	.023	. . . . .	.111	.10
Phosphoric acid	.738	.648	.535	.426	1.470	.65
Sulphuric acid	.065	.130	.037	.015	.120	.20
Chlorine	.007	.169	.012	.008	.038	.25
Silica, soluble	.155	.016	1.842	1.012	.285	.20
Silica, insoluble	5.069	2.042			. . . . .	. . . . .

*The lower paging.

It can be seen in these tables that the ash of the Hungarian grass, as well as that of the German millet, is remarkably silicious, and that a large portion of the silicious matter is in the insoluble condition.

At first, it was supposed that, although care had been taken to wash the plants thoroughly, much of this silicious matter might be excluded from the results of the analyses, as sand accidentally derived from the soil, and adherent as dust to the plants; but a more thorough examination, with the aid of the microscope, in the hands of our experienced microscopist, Mr. Alexander T. Parker, showed that much of it was in the form of a silicious skeleton of the plant tissue. This fact was made more manifest by digesting portions of the stem and leaves in diluted nitric acid, with and without the addition of chlorate of potash, until the organic matters were mostly decomposed and removed, when beautiful silicious skeletons were obtained, which, under the microscope, showed silicious casts or incrustations of the vegetable cells, and curious dumb-bell forms, proving that the silicious matter, in a dissolved state, had penetrated through the cell walls, and changing into the insoluble form, had incrusted the interior of the cells.

Some beautiful photographs were obtained by Mr. Parker, with the aid of our skilled photographer, James Mullen, directly from the enlarged microscopic images formed from the silicious residue, after digestion in the acid and subsequent ignition to destroy all the organic matters. The German millet gave fewer of the dumb-bell-like casts than the Hungarian grass, and the seeds of the former less than any.

DESCRIPTION OF THE MICROSCOPIC PHOTOGRAPHS.

No. 1. Silicious material of the stem of Hungarian grass, which had been digested for several days in nitric acid diluted with six parts of water, to which chlorate of potash was added and thorough washing. Magnified about 312 diameters, and photographed by Alex. T. Parker.

No. 2. A similar preparation from the leaf of this plant. Magnified about 312 diameters, and photographed by Alex. T. Parker.

These photographs of the purely silicious skeletons of the tissue of the vegetable leaf and stem are interesting as exhibiting casts of the cells, produced, no doubt, by the infiltration

of dissolved silicic acid, as also as showing, in their dumb-bell shapes, these cells apparently in the act of multiplication by the process of division.

It is well known to chemists that silica, in its ordinary separated state in the soil, is almost completely insoluble in water or the ordinary acids; but it is also well known that it takes the unstable soluble form of silicic acid when separated, by the decomposition of silicates by the action of acids in the presence of water. Doubtless the acid sap of the plants, coming in contact with the silicates of the soil, by osmose, caused this decomposition, and the relative amount of the silicious incrustation of the plant cells may give some measure of this local individual plant action on the soil.

It is well known the Hungarian grass is a very vigorous growing plant, even on soils comparatively poor, and that it is a very rough feeder, seeming to have greater power of assimilating insoluble, or difficultly soluble, soil ingredients than most other cultivated plants. Moreover, as is seen, it is eminently silicious. All these facts seem to show that it in some manner dissolves or decomposes the silicates of the soil in a greater degree than is common to most growing vegetables.

It has been known for a length of time that certain vegetables, especially of the lichen family, corrode the limestone, or even the basaltic or granitic rock or glass, on which they grow, and that, as was ascertained by Braconnet, some of these plants are known to contain oxalate of lime to the extent of half their weight. Other plants, as those of the lycopodium family, possess the power of dissolving and absorbing alumina by means of malic acid which they produce; so that the compound of this earth, so rarely found in vegetable tissue, is present in them in large proportion. That the roots of most plants, while alive or growing, give an acid reaction, is well known, and easy to verify by placing them in contact with blue litmus paper or infusion; but what is the nature or relative quantity of the acid or acids secreted by the various species of vegetables, or how they may act on the soil to decompose it, and in what manner their action may modify the

ash composition of the several plants, has not as yet been made a subject of systematic investigation.

It is well known that plants of different species, growing in precisely the same soil, will vary greatly in their mineral or ash constituents; and the late Baron Liebig was perhaps the first to declare (see Natural Laws of Husbandry, edited by John Blyth, M. D., New York, 1863, page 118) that "plants receive their food principally from the earthy particles with which the roots are in direct contact, out of a solution forming around the roots themselves." This solution, other things being equal, will vary according to the nature and quantity of the solvent, which solvent seems to be provided by the plants themselves, and secreted by the roots, and is evidently of an acid nature.

It is beginning to be generally understood that different plants secrete this acid solvent of the soil in different quantities, and probably of different strength and composition. Some of them, like the lichens which grow on the rock or lava surface, being able, by their special solvents, to extract their essential mineral elements from the hard material, which they thus decompose, while others, not being able to exert such a powerful decomposing and corroding agency, can only live on more soluble and available materials, which they may find in the decomposing remains of these pioneers of the vegetable world, or in solution in fertile soils generally.

To these special solvents—these peculiar digestive fluids of the vegetable kingdom—may very probably be attributed, in some measure, the special selective power of plants, by which different species, growing on the same soil, will appropriate to themselves not only very different quantities of the mineral elements, but different kinds of these matters; so that while one plant may be characterized by a large proportion of potash in its ash ingredients, another may always select a very large amount of lime, and yet another an unusual quantity of silica, &c., &c., and, practically, when a soil will no longer profitably produce one crop, it may yet be quite productive of another.

Some experiments of Dietrich, quoted in Johnson's "How Crops Feed" (pages 327–8), illustrate very clearly the different action of different plants in this relation. He caused these to grow in coarsely powdered sandstone and basalt rock, severally, watering them with equal quantities of distilled water, &c. He took also similar quantities of the same rocks and washed them with the same amount of the water, in order to exclude the mineral materials dissolved out of the rocks by the water alone. The special and very different solvent and decomposing action of the several plants on the rock materials is clearly shown in the following table, which we quote:

MATTERS DISSOLVED BY ACTION OF ROOTS.

	On 9 lbs of sandstone	On 11 lbs of basalt.
Of 3 lupin plants	0.608 grams.	0.749 grams.
Of 3 pea plants	.481 "	.713 "
Of 20 spurry plants	.268 "	.365 "
Of 10 buckwheat plants	.232 "	.327 "
Of 4 vetch plants	.221 "	.251 "
Of 8 wheat plants	.027 "	.196 "
Of 8 rye plants	.014 "	.132 "

The three pea plants extracted from these hard rocky materials more than forty times as much as the eight rye plants, and nearly twenty times as much as the eight wheat plants, under the same external conditions.

From the large proportion of ash ingredients in the Hungarian grass, and especially of silica, and its rank growth, it was considered probable by the present writer that it exerted an unusually great "root action" on the soil, by means of an acid solvent. To verify this supposition, some of this grass was gathered by him early in July, 1877, just as it was beginning to form its heads, and submitted to examination. The moistened roots, placed in contact with blue litmus paper, reddened it decidedly. A handful of the entire plants, which had been pulled up by the roots, the dirt having been shook off as completely as possible, was placed with the roots immersed in a saturated cold solution of carbonate of ammonia, and allowed to remain for twenty-four hours. The solution, which had

become of a light brown color, was then evaporated to dryness at a heat below 212° F. It left a dark brown residue, which was re-dissolved in water, filtered and precipitated with a solution of acetate of lead and a little ammonia. This precipitate, after washing with cold water, was suspended in water and decomposed with hydrogen sulphide, &c., and the filtrate, still somewhat colored, was tested for acids in the usual manner. It was found that oxalic and phosphoric acids were present in marked quantities, together with some malic acid, and probably a small amount of tartaric. Tannic acid was not observed.

Some of the same grass was gathered July 23d, when the seeds were beginning to ripen, and submitted to the same process, with very nearly the same results: the oxalic and phosphoric acids being found in largest proportions.

Some *buckwheat* plants, gathered on September 4th and 6th, when they were in full flower, were treated in a similar manner. Two handfuls of the plants were placed, successively, with roots immersed in the same saturated solution of carbonate of ammonia, each being allowed to remain in it twenty-four hours. The solution, which became also of a brownish color, treated in the manner above described, gave marked evidence of the presence of oxalic and phosphoric acids, with a notable quantity of malic acid, and small proportions of other vegetable acids; but no tannic acid could be detected with iron perchloride. The buckwheat roots did not react so decidedly acid with litmus paper as those of the Hungarian grass.

Although in these experiments the strong chemical affinity of the alkaline carbonate of ammonia may have caused the exosmose of more of the dissolved acids of the plant-sap than would pass out into any ordinary soil, and may have even exerted some decomposing action on the soft tissues or the fluids of the plants themselves, yet they are not without some value as indicating how, possibly, the plant may form a special solution, different probably for different species, in the immediate vicinity of the rootlets, of mineral substances in the soil which

may be insoluble in the ordinary surface waters. Researches into the nature of the special soil solvents of different plants may aid the practical farmer in the selection of crops in an ameliorating rotation, as it seems highly probable that some kinds of vegetables can exert a more powerful decomposing action on the silicates of the soil than others.

433

TABLE I. SOILS, SUBSOILS, UNDER-CLAYS, &c., DRIED AT 212° F.

Number in Report.	County.	Organic and volatile matters.*	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Sand and insoluble silicates.	Water, expelled at 380° F.	Water, expelled at 212° F.	Potash in the insoluble silicates.	Soda in the insoluble silicates.	Remarks.
1967	Allen	2.215	3.616	0.110	0.106	0.019	0.144	0 489	92.980	0.650	0.950	0.992	0.253	Virgin soil, Buncombe tract.
1968	Allen	2.045	5.872	.030	.097	.013	.160	.312	90.840	.615	1.250	.958	.209	Subsoil of the above.
1969	Allen	5.475	5.629	.520	.124	.156	.148	.210	85.740	2.200	2.425	958	.314	New upland soil, W. H. H Mitchell's.
1970	Allen	4.000	7.394	.470	.097	.141	.380	.175	85.090	1.625	2.215	.853	.242	Subsoil to the same.
1971	Allen	2.745	5.452	.070	.079	.083	.221	.143	90.440	.865	1.175	1.081	.354	Old field, same locality, &c.
1972	Allen	2.450	8.090	.080	.140	.045	.219	.115	88.040	.850	1.550	1.188	258	Subsoil to the same.
1973	Barren	4.175	7.365	.215	.197	.125	.209	. . .	86.065	1.575	1.865	1.227	.394	Virgin soil, barrens, Maj. J. S. Barlow.
1974	Barren	5.475	7.740	.465	.250	.275	.126	.004	82.990	2.275	2.500	1.074	.334	Old field, same locality, &c.
1975	Barren	2.615	8.323	.090	.197	.092	.308	. . .	86.665	.935	1.775	1.253	.373	Subsoil of the two preceding
1976	Barren	5.465	4.310	.340	.047	.125	.184	.029	87.470	1.800	2.150	.934	.300	Virgin soil (silicious grit), D. Davasher's.
1977	Barren	3.065	4.942	.225	.065	.093	.158	.053	90.185	1.015	1.500	1.102	.318	Old field, same locality.
1978	Barren	2.300	6.142	.125	.080	.093	.092	.055	89.985	.800	1.700	1.179	.256	Subsoil of the next preceding.
1979	Barren	4.700	4.632	.425	.161	.108	.069	.060	87.985	1.650	2.100	.722	.234	Virgin soil (silicious grit), Mrs. M. E. Davis
1980	Barren	3.450	4.622	.190	.061	.198	.126	.024	89.685	1.300	1.650	1.223	.381	Old field, same locality, &c.
1981	Barren	2.415	6.186	.190	.065	.124	.225	.086	89.650	1.000	1.735	1.151	.318	Subsoil of next preceding.
1982	Barren	4.150	5.967	.475	.017	.093	.105	. . .	87.710	1.325	1.800	1.156	.372	Old field, bottom land, same locality.
1983	Barren	3.725	6.034	.475	.115	.131	.161	. . .	87.835	1.375	1.900	1.127	446	Subsoil of next preceding.
1999	Fayette	4.325	12.168	.295	.214	.492	.268	.038	80.090	1.800	2.850	1.343	.359	Surface soil, lawn at Ashland.
2000	Fayette	3.535	15.666	.345	.331	.604	.372	. . .	77.715	1.300	3.375	1.273	.332	Subsoil of the same.
2008	Grant	5.515	13.849	1.420	.513	.636	.952	.082	77 640		5.710	2.524	.499	Subsoil, cut at station 295, section 29, C. S. R. R.
2009	Grant	5.400	12.675	1.465	.600	.435	.780	.617	78.965		5.950	2.511	1.214	Under-clay (hard pan?), same locality.
2010	Grant	5.425	6.847	.200	.420	.188	.568	.317	86.165		2.750	1.087	.388	Top soil, old fi'd, cut, st'n 30, sec. 30, C. S. R. R.
2011	Grant	4.100	9.199	.190	.420	.086	.156	.368	85.460	Included in the water and organic matters lost on ignition.	3.400	1.958	.260	Subsoil of same.
2012	Grant	4.450	11.672	.165	.398	.188	.579	.104	82.490		3.825	1.533	.638	Subsoil, just under next preceding.
2013	Grant	5 600	12.564	.225	.609	.236	.259	.246	80.115		5.950	2 004	397	Under-clay, just under next preceding.
2014	Grant	4.950	15.237	2.290	.383	.823	1.124	.019	75.240		6.575	2.410	407	Under-clay, just under next preceding.
2015	Grant	4.425	24.465	9 425	.286	.589	.669	.245	59.940		5.250	2.703	.265	Under-clay, just below next preceding.
2016	Grant	4.365	17.502	1.115	.151	.473	.809	.052	75.090		not est.	1.542	.297	Subsoil, section 33, second cut from north end.
2017	Grant	4.675	27.353	4.555	.266	.457	1.585	.125	60.967		not est.	1.487	.212	Under-clay, same locality.
2018	Grant	5.675	9.540	.575	.312	.345	.587	. . .	83 790		not est.	1.679	.510	Surface soil, sec. 34, second cut from south end.
2019	Grant	3.780	10.222	.290	.266	.313	.150	. . .	84.890		not est.	1.881	.552	Subsoil, same locality.
2020	Grant	6.290	18.593	.275	.402	.393	.611	.165	73.575		not est.	1.489	.486	Under-clay, same locality.
2021	Grant	6.085	15.437	1.225	.679	.473	.809	066	75.890		not est.	2.428	.376	Under-clay, below last, same locality.
2022	Grant	4.290	11.792	8.240	.824	.793	1.778	.359	71.924		not est.	2.423	.324	Under-clay, just below preceding.
2023	Grant	4.650	7.225	.470	.303	.185	.738	. . .	87.065		not est.	1.812	.722	Top soil, sec. 35, cut at north end, C. S. R. R.
2024	Grant	3.940	9.852	.390	.447	.358	.282	. . .	84 760		not est.	1.673	.677	Subsoil, same locality
2025	Grant	5.400	16.827	1.640	.645	.358	.213	.337	75.040		not est.	2.103	.433	Under-clay, same locality.
2026	Grant	4.450	14.492	2.315	.609	.358	.760	. . .	77.440		not est.	2.851	.417	Under-clay, below preceding
2027	Grant	5.025	21.124	4.305	.420	.361	.210	.308	68.515		not est.	2.700	.378	Under-clay, next below preceding
2028	Grant	5.850	23.100	3.640	.223	.505	.534	. . .	66 390		not est.	2.865	.449	Under-clay, under preceding.
2029	Grayson	3.239	3.096	.020	.097	.144	.160	.268	91 865	.506	1.200	.927	.262	Virgin soil, over the Leitchfield marl.

2030	Grayson. . . .	2.534	4.781	.045	.061	.159	.100	.102	91.490	.483	1.575	1.198	.254	Subsoil to the same.
2034	Hardin	4.495	5.579	.340	.286	.071	.149	.037	87.675	1.675	1.900	1.250	.435	Virgin soil, St. Louis limestone, Gov. Helm's.
2035	Hardin	2.575	6.520	.215	.227	.070	.119	. . . .	89.140	.950	1.510	1.037	.376	Old field soil, same locality.
2036	Hardin	2.350	9.807	.140	.223	.083	.270	. . . .	85.590	.925	2.050	.848	.265	Subsoil of the two preceding.
2037	Hardin	9.185	8.705	1.350	.124	.203	.595	.011	77.905	2.715	2.885	2.910	1.166	Virgin soil, St. Louis Group, J. W. Fowler's.
2038	Hardin	5 400	8.228	.625	.107	.172	.279	.018	83.090	2.075	2.315	2.226	.782	Old field, same locality.
2039	Hardin	4.500	8.347	.465	.142	.123	.175	.077	84.440	2.000	2.265	1.137	.733	Subsoil of preceding
2040	Hardin	4.610	6.033	.390	.070	.102	.316	.098	86.355	1.625	1.815	.956	.197	Virgin soil, St Louis Group, Vandecraft's.
2041	Hardin	3.085	6.597	.290	.040	.038	.035	.025	88.940	1.150	1.335	1.302	.443	Old field, same locality.
2042	Hardin	3.550	11.254	.215	.025	.061	.251	.168	83.490	1.550	2.575	1.329	.256	Subsoil of the preceding.
2044	Hopkins . . .	2.850	4.952	.080	.106	.083	.145	.050	90.540	.737	1.085	1 693	.687	Virgin soil, woods, Mr. Miles'
2045	Hopkins . . .	2.090	6.883	trace.	.181	.077	.307	. . . .	89.700	.660	1.285	1.458	.697	Subsoil of preceding.
2049	Logan.	2.900	3.247	.395	.115	.093	.132	. . . .	92.350	.875	1.435	.890	.301	Virgin soil, bottom land, W. Morton's.
2050	Logan.	2.585	7.095	.210	.196	.115	.169	. . . .	88.755	.765	2.385	1.334	.357	Subsoil to next preceding soil.
2051	Logan.	2.560	5.297	.195	.160	.093	.121	.068	90.935	.765	1.550	1.286	.299	Old field soil, same locality.
2052	Logan.	3.925	8.315	.640	.346	.125	.060	. . . .	85.035	1.275	2.675	1.212	.353	Black soil, unproductive, H. B. Tully's.
2053	Logan.	3.675	11.811	.245	.227	.109	.212	.015	82.365	.950	3.800	1.349	.266	Subsoil, St. Louis limestone, same locality.
2054	Logan.	2.775	4.812	.180	.170	.093	.085	. . . .	91.090	.600	1.250	1.474	.532	Old field soil, same locality.
2055	Logan.	3.048	9.158	.180	.214	.077	.326	.050	86 275	.775	2.525	1.320	.265	Subsoil, from same locality
2060	Madison . . .	5.825	10.434	.615	.043	301	.379	.094	79.965	2.415	3.165	1.537	.300	Red Bud soil. Covington farm.
2061	McCracken . .	2.050	5.497	.115	.268	.093	.167	.171	90.940	1 000	1.425	1.700	.598	Surface soil, L. M. Flournoy's.
2062	McCracken . .	2.650	12.300	.190	.521	.11	.284	. . . .	82.490	1.000	4 000	1 605	.911	Subsoil of the same.
2063	McCracken . .	2.675	10.834	.190	.649	.061	.643	.087	83.805	1.000	3.425	1.427	.668	Under clay of the same.
2064	Meade	3.565	5.091	.095	.133	.109	.156	. . . .	89.725	1.000	1.600	1 297	.471	Virgin soil, sandstone, Waverly G'p, McCarty's.
2065	Meade	5.665	15.741	.070	.242	.140	.425	. . . .	75.825	1.335	4.265	1.540	.304	Subsoil of the same.
2066	Meade	3.600	11.604	.045	.538	.156	1.082	. . . .	82 125	.650	2.950	2.259	.150	Under-clay of the same
2077	Oldham	4.612	4.449	.145	.313	.141	.388	.055	88 665	.713	1.900	1.281	.381	Virgin soil, Pewee Valley, Upper Silurian.
2078	Oldham	3.016	8.882	.195	.304	.098	.521	.117	86.465	.607	2.875	1.109	.444	Subsoil of the same.
2079	Oldham	4.215	5.010	.245	.250	.125	.138	.035	88.240	1.535	1.850	1.428	.663	Surface soil, white oak land, Pewee Valley.
2080	Oldham	3.250	9.008	.220	.178	.077	.349	.330	84.825	1.150	3.300	1.088	.022	Subsoil of the same.
	TEXAS SOILS.													
2088	Grayson. . . .	4.977	2.616	.880	.169	.124	.078	.052	89.690	.799	3.075	.670	.322	Black sandy soil, prairie, in cultivation.
2089	Grayson. . .	7.233	8.157	1.745	.223	.083	.211	.051	80.690	1.391	.605	.764	.159	Black waxy soil, prairie land
2090	Collins	7.097	11.447	17.085	.231	.143	.497	. . . .	61.840	1.660	.850	.443	.307	Black waxy soil, prairie land, in corn.

*Or loss by ignition after drying at 212°.

TABLE II. COALS, AIR-DRIED.

Number in Report.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Fixed carbon in the coke.	Ash.	Character of the coke.	Color of the ash.	Percentage of sulphur.	Remarks.
1995	Butler	not de'd	3.28	44.20	52.52	47.48	48.56	3.96	Spongy	Dark lilac-grey . .	3.060	Mining City Coal B'k, new op'ng, Mud Cr'k.
2031	Greenup. . . .	1.345	6.33	32 42	61.25	38.75	53.30	7.95	Dense spongy .	Light lilac-grey . .	1.277	Cane Cr'k Mine, new op'g, n'r Hun'w'l Fur.
2032	Greenup. . . .	1.344	5.77	33.28	60.95	39.05	52.40	8.55	Dense spongy .	Light lilac-grey . .	.900	Same locality (sample 2).
2033	Greenup. . . .	1.383	6.03	30.77	63.20	36.80	50.65	12.55	Dense spongy .	Light lilac-grey . .	1.458	Same locality (sample 3).
2058	Madison . . .	not de'd	3.57	36.53	59 90	40.10	55.77	4.13	Light spongy . .	Light yellowish-grey	.749	Marshall Moran's Bank, Big Hill.

TABLE III. IRON ORES (LIMONITE ORES), DRIED AT 212° F.

Number in Report.	County.	Iron peroxide.	Manganese oxide.	Alumina.	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Combined water.	Silica and silicates.	Percentage of iron.	Percentage of phosphorus.	Percentage of sulphur.	Percentage of silica.	Remarks.
2056	Lyon.	66.192	1.393		trace.	trace.	0.185	trace.	10.000	22.910	46.320	0.079	trace.	21.820	From Hall's patch drift.
2057	Lyon.	68.162	1.763		trace.	trace.	.505	trace.	9.630	20.150	47.703	.220	trace.	19.060	From Skillian Bank.
2081	Trigg	71.708	.945		trace.	trace.	.217	trace.	9.630	17.280	50.195	095	trace.	16.960	From one mile south of Centre Furnace.

TABLE IV. IRON ORES (CLAY IRON-STONES AND BLACK BAND ORES), DRIED AT 212° F.

Number in Report.	County.	Specific gravity.	Iron carbonate.	Iron oxide.	Alumina and manganese oxide	Lime carbonate.	Magnesia carbonate.	Phosphoric acid.	Sulphuric acid.	Silica and silicates.	Per cent. of iron.	Per cent. of phosphorus.	Per cent. of sulphur.	Per cent. of silica.	Bituminous matters and water.	Remarks.
2046	Jackson	not est	70.168	. . .	0.430	0.930	2.898	0.345	. . .	6.230	33.875	0.151	0.264	4.960	18.540	Black band ore, Coyle's Bank.
2069	Ohio	not est	90.012	not est	11.451	4.430	5.395	.377	trace	17.280	29.557	.146	trace	13.860	1.055	From Wm. Downe's Iron Mountain.
2070	Ohio	not est	69.117	not est	7.437	4.780	4.639	.786	.084	11.480	32.294	.343	.034	6.860	1.677	From Wm. Downe's Iron Mountain.
2071	Ohio	not est	48.211	9.227	7.307	5.880	4.298	1.805	.030	19.850	29 484	.475	.012	17.460	3.392	From Wm. Downe's Iron Mountain.

TABLE V. PIG IRONS.

Number in Report.	County.	Specific gravity.	Iron.	Graphite.	Combined carbon.	Manganese.	Silicon.	Slag.	Phosphorus.	Sulphur.	Total carbon.	Remarks.
2082	Trigg	6.872	92.349	3.380	. . . .	not est.	3.794	0.660	0.318	0.067	3.380	No. 1, foundry iron, Centre Furnace.
2083	Trigg	7.027	92.953	3.140	1.010	not est.	2.641	.100	.318	.074	4.150	No. 2, foundry iron, Centre Furnace.
2084	Trigg	7.183	93.946	2.860	1.060	not est	1.932	.360	.276	.104	3.920	No 3, mill iron, Centre Furnace.
2085	Trigg	6.934	91.173	3.400	. . . .	not est.	4.592	1.160	.262	.094	3.400	Mill iron, Trigg Furnace
2086	Trigg	6.864	89.576	1.000	1.380	not est.	6.637	1.560	.221	.121	2.380	Silver-grey iron, Trigg Furnace

TABLE VI. CLAYS, DRIED AT 212° F.

Number in Report.	County.	Silica.	Alumina.	Iron oxide.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water, expelled at red heat.	Remarks.
2007	Franklin . . .	69.300	21.780		*0.158	0 331	0.060	2.351	0 585	5.435	Potter's clay, bottom land, near Frankfort.
2074	Ohio	69 200	16.640	4.520	trace.	.893	trace.	3.102	.210	5.375	Indurated clay, below coal F, mouth of Brush Creek.
2075	Ohio	70.860	19.240	3.120	trace.	.425	trace.	2.351	.253	3.751	Clay, coal measures, near Elm Lick.
2076	Ohio	62.760	26.420	1.580	.325	trace.	trace.	.916	.268	7.731	Clay, Bald Knob Church, Caney precinct.

*Carbonate.

TABLE VII. MARLY SHALES, &c., DRIED AT 212° F.

Number in Report.	County.	Silica.	Alumina.	Iron oxide, &c.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water, carbonic acid, &c., and loss.	Remarks.
1994	Breckinridge .	66.960	15.626	8.380	0.493	0.677	0.154	3.295	0.628	3.787	Marly shale, Tar Hill, near Cloverport.
1996	Butler	51.660	15.560	7.680	7.269	.817	not est.	3.276	.293	13.445	Marly shale, below coal, Mud Creek Mines.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

CHEMICAL EXAMINATION

OF THE ASHES OF THE

HEMP AND BUCKWHEAT PLANTS,

WITH REMARKS ON ITS BEARING ON

HEMP CULTURE IN KENTUCKY.

BY ROBERT PETER, M. D., ETC., ETC.,
CHEMIST TO THE SURVEY.

CHEMICAL EXAMINATION OF THE ASHES OF THE HEMP AND BUCKWHEAT PLANTS, &c.

The hemp crop is of considerable importance in Kentucky agriculture, more especially in the richer portion, called the Blue Grass region, where the soil has been formed by the disintegration of the fissile layers of the lower Silurian limestone—rich in the mineral elements of plant nourishment.

According to the State Auditor's report, the gross amount of hemp fibre produced in our State was 18,981,819 pounds in 1872, and 21,375,306 pounds in the more productive, moist season of 1873.

Of this latter quantity seventeen counties, situated wholly or in part in the Blue Grass region, produced 21,194,445 pounds, and the five counties of Bourbon, Fayette, Jessamine, Scott, and Woodford produced 17,951,350 pounds. Mason county, the next in this industry, having also raised 828,300 pounds. It is, therefore, evidently a crop which is believed to be profitable only on our richest lands. The soil which best suits it is the rich, pervious, and well-drained loam, well charged with *humus* or the dark mould resulting from vegetable decomposition, such as results from the completely decomposed sod of recently cleared woodland pastures, or blue grass or clover ground, well plowed and made thoroughly fine and uniform in texture. Such land, in a favorable season, has been known to produce as much as 1,200 pounds of hemp to the acre, and it will yield an average of about 800 pounds for ten to fifteen years in succession, if properly managed, in ordinary seasons. As the price of hemp rarely falls below one hundred dollars per ton of 2,240 pounds, and this crop usually brings in cash, the great value of this industry is evident.

The hemp plant, under favorable conditions, is of most rank and luxuriant growth, attaining on our rich lands a height of ten to fourteen feet in favorable seasons, even when sown so thick, as is the practice, that it is closely crowded, and so completely covers the ground that not a weed can grow amongst it. It therefore requires a soil which can readily and quickly furnish to it the mineral elements necessary to its rank and rapid development, and at the same time furnish the large supply of moisture it requires without losing that highly porous condition and absorbing power which invites the penetration of the gases and vapors of the atmosphere, on which this plant is so greatly dependent for nourishment and growth.

The well-drained loam of this Blue Grass region, which is charged with black vegetable mould or *humus*, offers these conditions; the *humus* not only having great power of absorption, but containing in a soluble and available state the mineral elements of plant nourishment, and, moreover, acting as a solvent for those which are contained in the earthy constituents of the soil itself. We can therefore readily understand why the hemp plant thrives upon such land; but why so luxuriant a growth can be maintained on the same surface for ten to fifteen years in succession, without any material exhaustion of the soil, is another question.

The observing hemp farmer has long since arrived at a correct conclusion in this respect. He saw that while this most luxuriant plant produced an immense green crop, and required the richest soil to supply its rapid demand for nourishment during its short season of growth (of four months only), yet all its leaves and other green tissues, together with all that is removed from it in the process of dew-rotting, in the ordinary mode of hemp culture, are restored to the soil which produced it, and nothing is sold and carried off from the land but the cleaned hemp fibre, which, if well cleaned, contains very little but atmospheric elements, the removal of which can therefore cause but very little deterioration of the soil.

Moreover, during a great part of the year the ground is more or less shaded and protected, first by the growing plant,

then by the roots left in the ground after cutting, which somewhat diminish the washing action of rains and improve it in their gradual decay, as do also the leaves which fall and the hemp when spread on the ground to dry, after being cut, and lastly, when it is spread out upon it in the winter process of dew-rotting, as it is called, during which all the readily decomposable parts of the plant are washed out and decomposed by the rains and dews and the action of the air; enriching the surface soil beneath.

Managed in this way, and commencing with suitable rich land, the scientific observer understands, that although the growing plants may temporarily draw heavily on the soil for the mineral (earthy) ingredients necessary to their growth, amongst the most important of which are potash and the earthy phosphates, yet in the subsequent processes, the most of these are returned to the ground again in the decay of the leaves and other green parts, and in the soluble and decomposable matters which are leached out of the stems in the process of rotting; and that any small loss of these from the arable surface which may occur from the sale of the hemp fibre may be more than compensated by the action of the tap-roots in bringing them up from the lower strata of the ground. He understands further, that all the mineral elements thus restored, being left in organic combination in what is termed the humus or vegetable mould which results from this decay, are in a very soluble condition, and most available for the quick nourishment of the subsequent crop.

If the hemp plant, instead of being dew-rotted on the ground on which it had been grown, is entirely removed from it and submitted to the process of water-rotting, the culture becomes eminently exhausting to the land; mainly because so much of the elements of fertility is necessarily carried off in the water used. This was proved many years ago in relation to the flax crop of Ireland, in the chemical analyses of the water in which the flax had been steeped, and of the plant and the lint, by Dr. Kane; and experience to a certain extent in this region, in the water-rotting of hemp, has given the

same result. It is, perhaps, fortunate for our farmers, therefore, that this process, although several times proposed to them, has never been received with much favor.

The foregoing facts being of common experience, the writer desired, by the chemical examination of the mineral or earthy constituents of the hemp plant, as given in the *ash* in different periods and conditions of its growth, in different parts of the plant, and the various stages of its preparation, to study more fully the relations of this crop to the soil, and to understand, if possible, the true reasons why it is not an exhausting product when properly managed, as well as to learn the best conditions for its successful culture.

The first step in this investigation is to ascertain the average composition of the mineral ingredients of the entire hemp plant as given by the chemical analysis of its ashes; and as the works accessible to the writer give but very limited information on the subject, he procured from his own farm, and submitted to this analysis, five different samples, produced in two different seasons, grown under different conditions, and collected in different stages of their growth. The ashes of these, obtained by careful incineration at a moderate heat, were analyzed by the approved processes—several comparative analyses of the same ash having been made to secure greater accuracy—and the results are tabulated below in comparison with the average of two hemp-ash analyses published in 1865 by Professor Emil Wolff, of the Royal Academy of Agriculture, at Hohenheim, Wirtemberg, which are republished in the Appendix, page 378, of "How Crops Grow," by S. W. Johnson.

The samples examined may be described as follows:

Sample A. Entire hemp plants, including roots, leaves, &c.; collected on September 4th, 1874, when fully mature and ready for cutting; grown on somewhat elevated, very rich ground, the second year only from the broken up blue grass sod of woodland pasture, which had not been previously cleared or cultivated within the memory of the present race,

but which had been the site of a large circular earth-work* by the ancient mound-builders, and which seemed to have been enriched by a long residence upon it of these prehistoric people. The sample, notwithstanding the great fertility of the land, was very small, in consequence of *a continued drought which prevailed during the season of its growth*, it not being more than six to seven feet in height.

Sample B. Mature hemp plants, taken as it is usually cut, the roots and a small portion of the stems being left in the ground, and having only the top leaves, the others having fallen; collected September, 1873; grown on the field described above *in a very moist* and favorable season, so that it was very tall and large stemmed. The samples were about twelve feet high. Some hemp plants this year attained a height of fourteen feet.

Sample C. Six hemp plants entire, leaves, roots, and all; collected, before full maturity, on July 27th, 1874, from the same rich field, in the *very dry season.* The plants were about six feet high, and were in full leaf and in flower.

Sample D. Entire hemp plants, including roots, leaves, and immature seeds; grown on the experimental field selected by my son, Benj. D. Peter,† for practical experiments in hemp culture. This ground had been long in cultivation—at least fifty years. This sample was grown on lot 3, to *which about* 200 *pounds of plaster had been applied* early in the growing season. The sample was collected on September 8th, 1874. The plants were quite small, not more than from five to six feet high, in consequence of the continued drought of this season and the condition of the land.

Sample E. Similar to sample D; grown on the neighboring lot 4, of this experimental field, under similar conditions, except that *no plaster or any other fertilizer was applied to this lot.* A part of this lot 4, however, where a fence row formerly stood, happened to be somewhat richer than any part of this

*Fully described in Collins' History of Kentucky.

†See Prof. N. S. Shaler's Report.

or the plastered lot, as shown by the greater luxuriance of the growth of the hemp in that part.

F. The average of the analyses of the ashes of two entire hemp plants as given by Prof. Emil Wolff, as above stated.

In this table, as well as in the following ones, the carbonic acid of the ash is excluded in the calculations, for more complete comparison of the proportions of the *essential* mineral ingredients of the ash.

TABLE I. A. OF THE CHEMICAL COMPOSITION OF THE ASH OF THE ENTIRE HEMP PLANT, CALCULATED IN 100 PARTS OF THE ASH, WITH EXCLUSION OF CARBONIC ACID.

	A.	B.	C.	D.	E.	F.
Lime	38.482	31.299	48.689	50.623	45.263	43.4
Magnesia	8.558	6.017	6.445	8.576	11.225	9.6
Potash	37.475	43.739	29.118	23.519	23.933	18.3
Soda	.378	1.438	1.280	.472	.009	3.2
Phosphoric acid	8.667	14.164	10.384	11.721	13.233	11.6
Sulphuric acid	2.272	1.622	.940	1.472	1.445	2.8
Chlorine	.984	.522	.640	.301	.273	2.5
Silica	3.181	1.199	2.749	3.316	3.342	7.6
Per cent. of earthy phosphates	18.186	29.773	21.692	28.460	27.427	....
Per cent. of ash to the air-dried plants, carbonic acid excluded	4.223	2.563	5.055	4.126	4.203	4.6
Per centage of ash, carbonic acid included	5.569	3.357	6.754	5.288	5.346	....

This table shows some notable differences in the ash proportions and composition. For example, sample B, grown in the moist season, as compared with the others grown during the drought, gave a smaller ash per centage to the dried plants; its ash contains smaller proportions of lime, magnesia, and silica, and larger proportions of potash, soda, and phosphoric acid.

The immature sample C, gathered in July, as compared with the other samples (A, D, and E) of the same dry season, which were gathered in September, shows a larger per centage of ash to the dried plants.

The samples D and E, grown on the old land, while they give about the same average of ash to the dried plants, show a smaller proportion of potash.

Not much importance is attached to the proportion of silica, which is evidently stated much too high in the analyses quoted by Wolff. The hemp plant, being somewhat viscid on its exterior, always has more or less fine silicious dust adhering to it, derived from the soil, which cannot be removed by washing the plants. This the writer attempted to exclude, in his analyses, by dissolving the ash in diluted acid (nitric or chlorohydric), and excluding all that remained undissolved as most probably fine earth accidentally adhering to the plant. This may, in some cases, be a slight cause of error, but probably not so great as the retention and analysis of the adhering fine dirt with the plant ash, which seems to have been done in the analyses quoted by Wolff. For the same reason the alumina and iron oxide were also excluded.

The real significance of these differences of proportion and composition of these ashes can better be seen where the comparison is made with the proportions of the dried plants themselves to the several ingredients of the ash, as given in the following table:

TABLE I. B. OF THE QUANTITIES OF THE ASH INGREDIENTS IN 100 PARTS OF THE AIR-DRIED HEMP PLANTS, CARBONIC ACID EXCLUDED.

	A.	B.	C.	D.	E.	F.*
Lime	1.624	0.802	2.461	2.103	1.968	1.74
Magnesia	.361	.154	.312	.356	.475	.30
Potash	1.582	1.121	1.472	.977	1.012	.74
Soda	.016	.037	.065	.019	a trace.	.1[illegible]
Phosphoric acid	.366	.363	.525	.488	.560	.47
Sulphuric acid	.096	.042	.047	.061	.061	.10
Chlorine	.041	.013	.022	.012	.011	.10
Silica	.134	.031	.139	.135	.141	.30
Per cent. of earthy phosphates	.768	.763	1.103	1.182	1.150	. . . .
Per cent. of ash to dried plants	4.223	2.563	5.055	4.126	4.203	4.00

* See Wolff's tables, "How Crops Grow," page 383. Calculated to the dried plants.

This table shows, that while the smallest proportion of mineral or ash ingredients, to the dried plants, was given in the season when the hemp had a luxuriant growth because of the regular supply of moisture, the difference was occasioned mainly by the greater quantities of lime, magnesia, and silica in the plants of the dry season, and not by any material variations in the proportions of the alkalies or phosphoric acid.

It is well known that the external tissues of all growing plants become more or less charged with earthy salts, especially carbonates of lime and magnesia with some phosphates, which have been carried from the soil to their surfaces in solution in water containing carbonic acid (which is in all the water of the soil) and left there in a form insoluble in water upon the escape of that acid and the evaporation of the water which brought them up. As all the moisture of the fertile earth contains this solution, which is drawn up and evaporated from the general surfaces of the plants exposed to the air, it can readily be seen, that because of the greater evaporation and the more concentrated nature of the soil solution, in the dry season, there must necessarily be a larger accumulation of this surface deposit in the dry than in the moist or wet season, when evaporation is measurably checked. For the same reason the ash per centage of the leaves and bark of plants is greater than that of the interior parts, and that of the leaves of deciduous plants greater than that of the leaves of evergreens, which give off less water by evaporation.

The effect of this evaporation has very justly been compared to the deposit of the limestone crust in the steam-boiler and the formation of stalactites in caves; and this irregular increase of the ash per centage causes many apparent discrepancies in the mineral ingredients of plants, and increases the difficulties in the chemical study of plant nourishment; for while it is generally admitted as fully demonstrated, that certain mineral ingredients, to be found in the ashes of all vegetables, are essentially necessary to their growth, it must be acknowledged that some or some portion of these ingredi-

ents are of no more significance than the incrustation in the steam-boiler; being mere accidental deposits on the surface, the result of the escape and evaporation of the agents, water and carbonic acid, which held them in solution in the sap of the plants and in the water of the soil.

In the same manner may we explain the influence of a dry season in increasing the fertility of the surface of the soil; the soil solution, on the evaporation of the water, leaving its dissolved salts and other ingredients upon the surface; so that seasons of long drought are usually followed by others of great productiveness when there is sufficient moisture.

The larger ash per centage of sample C is mainly due to this cause; the leaves not having fallen, which yield a very large proportion of ash.

The ashes of samples D and E, grown on the old land in the very dry season, while not differing much in their general weight-proportion to the dried plants, show more lime and less alkalies than that of the hemp grown on the richer land. For some reason not immediately apparent, perhaps because of a previous buckwheat crop, they gave rather more than the average quantity of earthy phosphates.

In the usual mode of management of the hemp crop the leaves mostly fall on the ground on which it is grown. A large proportion of them drop before the hemp is cut, more fall when it is spread on the ground to dry after cutting, and when it is taken up to be stacked. It would be well, doubtless, to beat off, in this process, all the leaves that can thus be separated, so that they may be more regularly distributed over the soil than if thrashed off when stacking it. It is also the general practice now to cut the hemp as nearly as possible to the surface of the ground, and leave the roots, with a few inches of the stem attached, to rot in the soil.

In order to ascertain the relative fertilizing influence of the leaves and roots, three hemp plants were collected, July 25th, 1864, in *the dry season*, from the rich field above described. These, one male and two female plants, were about six to

seven feet high. The leaves, stems, and roots, carefully separated and thoroughly air-dried, weighed as follows:

The leaves weighed 23.916 grammes, equal to about 30. per cent. of the whole plant.
The roots " 7.433 " " 9.3 " "
The stems " 48.430 " " 60.7 " "

These were separately incinerated and their ashes analyzed, with the following results:

TABLE II. OF THE RELATIVE ASH INGREDIENTS OF THE LEAVES, ROOTS, AND STEMS OF THE HEMP, CARBONIC ACID EXCLUDED.

	THE LEAVES.		THE STEMS.		THE ROOTS.	
	In 100 p'ts of ash.	In 100 p'ts of dried leaves.	In 100 p'ts of ash.	In 100 p'ts of dried stems.	In 100 p'ts of ash.	In 100 p'ts of dried roots.
Lime	8.819	4.992	23.371	0.949	20.368	0.713
Magnesia	5.726	.585	5.803	.194	8.297	.291
Potash	27.955	2.858	49.599	1.659	52.233	1.829
Soda	.236	.024				
Phosphoric acid	9.264	.947	13.374	.447	15.164	.531
Sulphuric acid	2.209	.226	1.215	.040	1.344	.047
Chlorine	.171	.017	.576	.019	.405	.014
Silica	5.620	.575	1.062	.035	2.189	.077
Per cent. of phosphates	19.160	1.959	28.158	0.942	26.885	0.949
Per cent. of ash	....	10.225	....	3.346	....	3.502

By examination of the above table it is to be seen, that the leaves of the flowering hemp contain more of the essential mineral ingredients of the soil than all the other parts of the plant; constituting, as they do, about 30 per cent. of the whole plant in the air-dried state, and yielding 10.225 per cent. of their weight of ash, the carbonic acid being excluded; while the stems and roots, which together form the remaining 70 per cent. of the weight of the plant, give an average of less than 3.5 per cent. of ash.

Nor is this great excess of the ash proportion in the leaves due entirely to the influence of the greater evaporation which takes place on their surfaces, causing a deposit or incrustation of lime and magnesia salts and silica of the nature of stalagmites; for we see that whilst the amount of *silica* in the leaves is nearly fourteen times greater than that in the stems, and

more than seven times greater than in the roots; the *lime* more than five times as great as that in the stems, and seven times more than in the roots; the *magnesia* three times more than that in the stems, and twice as much as that in the roots; the *phosphoric acid* and *phosphates* and the *alkalies* are in nearly double proportion in the leaves also, and the sulphuric acid five times greater in them than in the stems, and about four times greater than in the roots. So that whilst the leaves, when in their fully matured state or when they naturally fall, may possibly contain scarcely any but the less soluble salts which may be left in their tissues on the evaporation of the carbonated water which held them in solution in the sap, they contain, when in the growing, active condition, like all other green herbage, a very large proportion of salts of potash, and of all the mineral elements of plant nourishment, and hence may greatly enrich the soil on which they decay. It is obviously to the interest of the hemp farmer, therefore, so to manage as to spread them as regularly as possible over his hemp ground.

The dried hemp plants are allowed to remain in the stack until the cool season of early winter, when they are generally spread out evenly upon the same ground on which they had been grown, to undergo the process of dew-rotting. The hemp is permitted to remain on the ground until, by the action of the atmospheric waters and other agencies, it has become so far decomposed that all its soluble parts and soft tissues are removed and washed into the soil beneath or dissipated in the air, and the tough hemp fibre can be easily separated from the more woody portion of the stems. It is then taken up, "braked" out, and the clean merchantable hemp fibre separated from the "hemp-herds," or "*hemp shives*"—the broken fragments of the woody parts of the stems—which are usually burnt up by the hemp-brakers on the spots where they fall near their hemp-brakes.

In order to study the changes which occur in the mineral constituents of the hemp during this process of dew-rotting, samples of dew-rotted hemp plants, ready for the brake, were

gathered, in December, from the two lots of the experimental field above mentioned, of the crop of the dry season of 1874. These were thoroughly air-dried, incinerated, and their ash submitted to analysis, with the following results:

TABLE III. OF THE ASH ANALYSES OF DEW-ROTTED HEMP PLANTS, CARBONIC ACID, &c., EXCLUDED.

	(D) SAMPLE FROM LOT 3. PLASTERED. (SEE D.)		(E) SAMPLE FROM LOT 4. NOT PLASTERED. (SEE E.)	
	In 100 parts of ash.	In 100 parts of dried hemp plants.	In 100 parts of ash.	In 100 parts of dried hemp plants.
Lime	68.846	1.235	63.651	0.942
Magnesia	8.335	.149	8.343	.124
Potash	5.716	.102	5.682	.084
Soda	.429	.008	.760	.012
Phosphoric acid	13.979	.251	15.713	.233
Sulphuric acid	.965	.017	1.552	.023
Chlorine	.050	.001	.042	.001
Silica	1.680	.030	4.257	.063
Per centage of earthy phosphates	27.144	.487	29.920	.443
Per cent. of ash to the dried rotted hemp	.....	1.793	.....	1.480

On comparing these results with those given in tables I. A. and I. B., in the columns D and E, where the results of the analyses of the ashes of this same growth of hemp are given in the *unrotted* state, it will be seen that a great diminution has taken place in the amount and proportions of the ash and its several ingredients.

To exhibit this diminution of the ash ingredients, which takes place in the ordinary process of dew-rotting, we place the averages from table I. B. and the above table side by side in

TABLE IV. COMPARATIVE VIEW OF THE ASH OF THE UNROTTED AND THE DEW-ROTTED HEMP PLANTS, CARBONIC ACID BEING EXCLUDED.

	Average of D and E. Unrotted hemp plants.	Average of D and E. Dew-rotted hemp plants.	Proportions removed by dew-rotting.
Lime	2.036	1.089	About one half.
Magnesia	.415	.136	Nearly two thirds.
Potash	.995	.093	More than nine tenths.
Soda	.019	.010	About one half.
Phosphoric acid	.524	.242	More than one half.
Sulphuric acid	.061	.020	About two thirds.
Chlorine	.011	.001	Ten elevenths.
Silica	.138	.047	Nearly two thirds.
Per cent. of earthy phosphates	1.166	.465	More than one half.
Per cent. of ash to the dried plants	4.165	1.636	More than one half.

When we also take into consideration the fact that the dried hemp plants lose at least one third of their weight in the dew-rotting, we can judge how large a proportion of the essential mineral ingredients are restored to the soil in this process.

The above table also shows us that the more soluble ingredients, such as the alkalies, &c., are removed from the plants in the larger proportions.

These analyses and comparisons enable us clearly to understand why the culture of hemp, when judiciously managed, especially when it is spread out and dew-rotted on the same surface on which it was grown, is so little exhausting to the soil, as compared with the method in which the water-rotting process is used.

In order to ascertain how much of the essential elements of the soil are carried off in the merchantable product—the hemp fibre as ordinarily sold—analyses were made of some of this, both in the usual condition as it is to be found in our hemp factories, and after it had been well washed with water to remove from it as much of its adhering dirt and soluble matter as possible.

Two samples of the "hemp-herds," or refuse woody portions of the stems, separated in the operation of braking, were also incinerated, in the air-dried state, and the ashes

submitted to chemical analysis. The results are given in the following table:

TABLE V. COMPARISON OF THE ASH INGREDIENTS OF DEW-ROTTED HEMP FIBRE AND HEMP HERDS, CARBONIC ACID EXCLUDED.

	HEMP FIBRE, UNWASHED.		HEMP FIBRE, WASHED.		HEMP-HERDS, 1873. MOIST SEASON.		HEMP-HERDS, 1874. DRY SEASON.	
	In 100 pt's of ash.	In 100 p'ts of dried hemp.	In 100 p'ts of ash.	In 100 p'ts of hemp.	In 100 p'ts of ash.	In 100 p'ts of dried herds.	In 100 p'ts of ash.	In 100 p'ts of dried herds.
Lime	59.960	0.984	68.694	0.722	51.998	0.446	62.992	0.676
Magnesia	8.512	.141	6.222	.065	8.426	.072	8.966	.097
Potash	7.351	.121	3.789	.040	19.615	.168	8.670	.093
Soda	.712	.012	.801	.008	.915	.008	.754	.008
Phosphoric acid	15.852	.260	15.335	.161	14.401	.124	12.215	.131
Sulphuric acid	1.710	.029	.487	.005	2.016	.017	2.138	.023
Chlorine	.092	.002	.048	.001	a trace.	a trace.	a trace.	a trace.
Silica	5.621	.092	4.624	.049	2 629	.022	4.465	.048
Per cent. of earthy phosphates	31.567	.518	29.486	.310	29.275	.251	24.807	.267
Per cent. of ash to the air-dried material	.....	1.642	.....	1.051	.....	.859	.....	1.076

The hemp fibre, which was analyzed in the ordinary unwashed condition, was obtained from a factory in Lexington. It was of the crop of 1874, dark colored, and containing, perhaps, more than the average quantity of dirt or fine soil adhering to it. Washing with cold water removed some but not all of this adhering dirt, as well as much of the soluble matters contained in it, reducing the per centage of the ashy residue more than one third. Had it been thoroughly cleaned and bleached the ash per centage would have been still more considerably reduced. All the nitrogenous matters, holding phosphates in a comparatively soluble condition, all the alkaline salts, would thus be dissolved out, and very little else than silica, with a small proportion of the earthy carbonates, would be left in the clean hemp fibre; so that exhaustion of the soil from its production would be quite insignificant.

Calculating on the data of the above tables, we find that an average crop of hemp of 800 pounds to the acre removes from the soil only a little more than thirteen pounds of ash ingredients, or, when in the washed condition, less than eight pounds and a half, while it is well known that a crop of wheat of twenty bushels takes nearly twenty pounds in the grain

alone; a crop of fifty bushels of corn removes more than thirty pounds in the grain alone, and a crop of tobacco of one thousand pounds, more than one hundred and seventy-six pounds.

When we compare the relative proportions of the ingredients of these several ashes, the result is still more to the advantage of the hemp crop, as is to be seen in the following table:

TABLE VI. OF THE PROPORTIONS OF MINERAL INGREDIENTS REMOVED FROM THE SOIL IN CERTAIN AVERAGE CROPS.

	In 800 lbs unwashed hemp.	In 800 lbs of washed hemp.	In 20 bus'ls of wheat *	In 50 bus'ls of corn.*	In 1,000 lbs tobacco, including the stalks.*	In 2,400 lbs of ordinary hemp-h'ds.
Lime, in pounds	7.872	5.776	1.63	0.22	68.00	10.704
Magnesia, "	1.128	.520	2.43	3.61	8.67	1.728
Potash, "	.968	.320	5.45	8.06	69.73	4.032
Soda, "	.096	.064	.13	6.22	6.80	.192
Phosphoric acid, "	2.080	1.288	9.12	11.85	8.13	2.976
Sulphuric acid, "	.232	.040	.08	not est.	8.40	.408
Chlorine, "	.016	.008	.35	not est.	1.06	a trace.
Silica, "	.736	.392	.41	.71	5.86	.528
Total ash	13.128	8.408	19.60	30.67	176.65	20.568
Total earthy phosphates	4.144	2.480	. . . .	. . . .	. . . .	6.024

* From volume IV, Reports of Kentucky Geological Survey (old series), page 321.

We see that while an average crop of hemp takes only an amount of potash from the acre varying from less than one pound to less than one third of a pound, the wheat crop takes nearly five and a half pounds, the corn crop more than eight, in the grain alone, and the tobacco crop nearly seventy pounds; and while the hemp crop carries off only from one and a quarter to two pounds of phosphoric acid, the wheat will take more than nine, the corn more than eleven, in the grain alone, and the tobacco more than eight pounds. We notice also that the removal of the hemp-herds (which are believed by some of our practical farmers to bear a proportion in weight to the hemp fibre of three to one) will take from the land greatly more of its essential ingredients than the hemp fibre itself; for while the merchantable hemp holds less than a pound of potash and two pounds of phosphoric acid in its composition,

the equivalent quantity of hemp-herds holds more than four pounds of potash and nearly three pounds of phosphoric acid.

As we have stated, it is the common practice of our farmers to permit the hemp-herds to be burned up in the heaps where they fall near the hemp-brakes. Some erroneously believe, indeed, that they would exert an injurious or poisonous influence on the land if spread over it; but it is evident that this practice tends more rapidly to reduce the fertility of the hemp field than the sale of the hemp fibre; and that it would be beneficial to adopt some plan of reducing the hemp-herds to the condition of vegetable mould, and to spread it over the surface, where it would not only tend to keep up the proportion of humus, but would re-supply much of the essential mineral elements in a soluble or available form. If it is found that the recently scattered hemp-herds seriously interfere with the cultivation or growth of the next succeeding hemp crop, it would doubtless pay to haul them into heaps to rot, or to spread them over some other field, which might be in preparation for hemp in a system of rotation adapted to this culture.

The common practice in our region has been to cultivate the rich new land in hemp continuously until it no longer yields a profitable product, and then to resort to other newly-cleared woodland pasture, or open blue grass fields, to renew the process. Sometimes land comparatively old in cultivation has been used for hemp, after it has been rested and has increased its humus during two or three years in clover, or for a longer time in open blue grass pasture; but as yet no regular system has been adopted by which the abundant humus and ready supply of soluble mineral ingredients of the soil, necessary to this luxuriant vegetation, can be secured or maintained. As the hemp product carries but little of these away from the land, leaving most of them behind, after a temporary use of them during its season of growth, the maintenance of the productiveness of the hemp soil seems an easy problem to solve, where the land is well drained and naturally of a suitable composition and consistence, as is our blue grass

land. But the capability of the production of hemp, even in this fertile soil, appears to be limited, and its humus and other soluble essential ingredients, on the abundance of which this crop is so greatly dependent, seem gradually to undergo diminution in the ordinary system of culture.

That this gradual deterioration is not due wholly to the removal of the crop is evident from the foregoing facts and considerations. But it appears that the humus and its soluble and available constituents are decomposed and removed, under the influence of the atmospheric agencies, faster than they are renewed by the decay of the leaves and other decomposable parts of the hemp plant. The small proportions of these carried off in the merchantable hemp need, indeed, scarcely be taken into consideration in this connection.

The humus is a very decomposable and oxidable substance; the atmospheric oxygen combines continuously with its carbon and hydrogen to produce carbonic acid and water, so necessary as plant food, while the essential mineral elements of the mould thus set free, being in a soluble condition, are subject to the washing agency of water, which may diffuse them more or less through the neighboring fields, or gradually carry some of them off in the drainage. This action would be the greatest when the ground is no longer covered with a growing vegetation, which would absorb the rich soil solution and bring its valuable fixed ingredients to the surface, but is doubtless constant whenever water in sufficient quantity falls to saturate the soil or to pass through it. For although many experimenters have established the fact that the soil has a power of absorption sufficient not only to enable it to withdraw and hold certain substances dissolved in the water which passes through it, and even to decompose some chemical compounds, and to separate and hold some of the elements and replace them by others less essential, yet it is equally well established by numerous experiments that pure water, such as rain water, which passes through a fertile soil, carries off from it, in solution, a notable quantity of its essential elements, which, as already intimated, may either be lost to the locality by the

drainage or diffused through the adjoining grounds, according to the well-known laws of osmose.

To maintain the high degree of active fertility necessary to successful hemp culture, even in our rich blue grass lands, seems, therefore, to require something more than the most judicious management of that crop itself; for we find that, although the removal of the hemp causes a scarcely sensible diminution of the mineral elements of the soil, the field on which it is continuously produced for a series of years becomes at length unproductive of this crop, because, doubtless, of a gradual decrease of its proportions of humus and of those soluble salts which are required by the hemp plant in such a large and ready supply as is necessary to its rank and rapid development, during its short season of growth.

As the prevalent mode of culture, if carried on indefinitely, would inevitably reduce all our hemp lands below the level of profitable production, the adoption of a new system, which would promise greater durability to hemp culture, is greatly desirable.

According to the prevalent system, the hemp ground is exposed, more or less, to the decomposing and leaching influence of the atmospheric agencies for more than six months in the year, with scarcely any growing plant upon its surface to absorb and retain the dissolved fertilizing materials or the nutritive gases which are produced in it by decomposition. These, therefore, may pass off in the drainage or become lost to the field by the continuous process of diffusion.

The growth of the hemp begins early in May; it is ended, by the cutting of the crop, late in August. During these four months it is probable the active vegetation absorbs and retains the dissolved essential elements of the soil, so that waste of them by oxidation, diffusion, or drainage, is little or nothing. The drying of the cut hemp spread on the ground is a short process, and the subsequent influence of the roots of the hemp left in the ground is merely mechanical, and does not prevent oxidation of the humus or the leaching out or diffusion of its soluble materials; neither does the hemp, when

spread out to dew-rot, prevent this action of the atmosphere or the water, although it may give much soluble fertilizing matters to the soil; and very few weeds of any kind spring up in the hemp field to take up and retain for future use these valuable gaseous and soluble substances which pervade the soil, and are escaping, mostly in solution, in all the water which passes through it.

The obvious remedy for this loss is to keep the surface of the ground, as much as possible, covered with an active vegetation which would absorb and retain upon the surface these fleeting elements of fertility, and keep up, in its subsequent decay, the large proportion of humus which is necessary to a heavy hemp production.

Some of our farmers, for this purpose, have very judiciously resorted to the sowing of rye after the cutting of the hemp, to be plowed in, the following spring, as early as may be necessary to kill it and allow it to rot. The rye grows with great vigor and covers the ground fully; is not injured by the hardest frost, and offers no impediment to the dew-rotting of the hemp, while its roots continually absorb the soluble and gaseous elements of plant food, to retain them and leave them in an available state, together with a new supply of humus, when it is plowed in to decay in the soil. If at the time of sowing the rye the ground is also plowed and the hemp roots covered to rot, no doubt the surface could be more benefited than if the grain is simply sown on the surface and harrowed in.

Some definite idea of the beneficial influence of the rye may be obtained by examining the results of the analyses of this plant in its immature condition, as given in the tables of Emil Wolff and Dr. Emmons, of New York. (See table in Johnson's "How Crops Grow" and "Natural History of New York.")

It would be quite a moderate estimate to say that rye, sown on the rich hemp ground in early September and plowed in early in April or late in March, would give to the land an amount of vegetable matter, in its roots and leaves, equal to three thousand five hundred pounds, in the dried condition, to

the acre, which by its decay would greatly increase its vegetable mould or humus, and probably replace fully that portion which had been removed in the hemp culture. But we find, by reference to the table of Wolff, that this amount of organic matter would also give to the soil more than sixty-six pounds of potash; more than twenty-five pounds of phosphoric acid; nearly thirteen pounds of lime; more than five pounds of magnesia; more than two pounds of sulphuric acid, and equally considerable quantities of soda, chlorine, and soluble silica; in all more than one hundred and seventy pounds of essential mineral ingredients to the acre, in a state most favorable for plant food, or nearly twenty times as much as need be carried off in an average crop of merchantable clean hemp fibre. This use of the rye plant evidently commends itself to the careful and judicious hemp farmer for a full and thorough trial.

Another important question with our hemp farmers is, how best to improve our old fields to a new capability of profitable hemp culture? Such is the natural fertility of our blue grass soil, and so very favorable are the conditions to which it is subject, that this is a more easy problem than is generally supposed. Indeed, our routine farmers find by experience that a good clover rotation, or a series of years in blue grass sod, will ordinarily recuperate a field to hemp land. The soft Silurian limestone beneath it is constantly, although slowly, yielding up its stores of fertilizing elements to the atmospheric waters, which gradually dissolve it and bring them by diffusion into the soil for the use of growing plants. But the demands of the farmer upon the soil most generally exceeds this beneficent supply of fertilizers, and hence his fields decrease in productiveness in the ordinary thriftless husbandry which has been kept up by this liberality of nature, and he is already confronted with the necessity, either for the use of artificial fertilizers or the adoption of such a system of rotation of crops as will give time for the natural recuperation of his soil, without a serious diminution of his annual income. The latter alternative commends itself most in our region, and especially a rotation which includes a clover fallow of two years. The

red clover growing with great vigor on our ordinary soil; producing a great amount of herbage; drawing largely from the atmospheric gases and vapors, and reaching to considerable depths in the soil for mineral fertilizers with its long tap roots; so that experience proves it to be the best known plant for the renewal of our land, in our common rotations, more especially because it can be pastured with hogs or cattle without a very serious diminution of its ameliorating influence upon the soil. When cut for hay, which is removed from the field, the case is very different, as can be understood when we see that a clover hay crop of two tons carries off with it not only the equivalent of humus which its decay on the soil would give, but also more than eighty pounds each of potash and lime, nearly twenty-three pounds of phosphoric acid, and other fertilizing mineral substances in proportion.

The ash of the dried clover and dried green hemp plant are strikingly alike in composition, as may be seen in the following table:

TABLE VII. OF THE RELATIVE PROPORTIONS OF THE ASH CONSTITUENTS OF CLOVER AND HEMP PLANTS, &c.

	In 100 parts of the dried hemp. From table I. B. (Sample C.)	In 100 parts of dried clover. (E) From Wolff's tables.*	Mineral ingredients in an acre of clover, including the roots. (Say 5,000 lbs., dry.)	
Lime	2.461	2.30	115.00	pounds.
Magnesia	.312	.80	40.	"
Potash	1.472	2.30	115.	"
Soda	.065	.10	5.	"
Phosphoric acid	.525	.65.	32.5	"
Sulphuric acid	.047	.20	10.	"
Chlorine	.022	.25	12.5	"
Silica	.139	.20	10.	"
Per cent. of ash	5.055	6.80	340.	pounds.

*The average of fifty-six analyses.

That the clover fallow may be made very useful in the renovation of our hemp lands, by a judicious management, is manifest.

But other plants of a quicker growth may sometimes enter into an improving rotation for this crop, and no other promises

better than the *buckwheat plant*, in ordinary seasons, which may afford moisture enough for its luxuriant growth.

During the present year my son, Benj. D. Peter, devoted one lot in his experimental field (see Prof. N. S. Shaler's report) to buckwheat, sown broadcast in the spring, in order to study its ameliorating influence on the soil when plowed in. The season being a very wet one, the plants grew with great luxuriance and fully covered the ground. Samples of it were gathered by me, roots and all, on June 20th, when it was in full leaf and in flower at the top; and also on August 4th, when it was about three feet high, yet in flower at the top, and had matured a good deal of seed. It had, of course, then lost most of its lower leaves. These samples were fully air-dried in the laboratory, incinerated, and the ashes fully analyzed, with the following results:

TABLE VIII. OF THE COMPOSITION OF THE ASH OF THE BUCKWHEAT PLANT, &c., CARBONIC ACID EXCLUDED.

	BUCKWHEAT IN FLOWER.		BUCKWHEAT IN SEED.	
	In 100 parts of the ash.	In 100 parts of dried plants.	In 100 parts of the ash.	In 100 parts of dried plants.
Lime	33.434	2.99	35.103	2.131
Magnesia	10.518	.922	12.586	.764
Potash	32.900	2.883	26.180	1.589
Soda	1.266	.111	.657	.040
Phosphoric acid	16.824	1.470	23.770	1.443
Sulphuric acid	1.378	.120	not est.	not est.
Chlorine	.431	.038	.350	.021
Silica	3.249	.285	1.354	.083
Per cent. of earthy phosphates	32.873	2.880	47.198	2.865
Per cent. of ash in dried plants	.....	8.762	.....	7.479
Per cent. of dried to green plants	.....	18.000	.....	29.000

This crop of green herbage was plowed under shortly after the last sample was gathered, in the hope that the matured seed would germinate and produce a second growth to be plowed under in the fall. Many did sprout, but the grasshoppers consumed most of the young plants.

Before plowing this buckwheat under, the green growth on a yard square was weighed, and amounted to four and three quarter pounds, which is equivalent to about 22,990 pounds to the acre, equal to more than six thousand pounds, or three tons, of the dried plants, including the roots, to the acre of ground. So that, calculating on the data given in the above table, this large quantity of green herbage, with the seeds and roots included, would not only give to the surface the large amount of humus, or vegetable mould, which would result from its decomposition, but also more than ninety-five pounds of potash; more than eighty-six pounds of phosphoric acid; nearly one hundred and forty pounds of lime; nearly forty-six pounds of magnesia, and other essential ingredients in proportion; all in a state immediately available for plant nourishment.

The experience of another season may demonstrate its practical effect in an increased hemp production.

The buckwheat plant is used in other regions as a fertilizer, and may very properly be introduced here in a rotation. It is evident that future profitable hemp culture will depend greatly on the adoption of a judicious rotation of crops suited to our soil and markets. What the details of that rotation may be must be worked out by our intelligent farmers.

INDEX.

[The figures refer to the bottom paging.]

Action of plants on rock materials . . . . . 431 to 433
Airdrie Furnace iron ores, &c. 145, 148, 149, 151, 153
Allen county; composition of soils and subsoils of . . . . . 355 to 358, 434
Analysis of, &c. See Composition of, &c.
Analyses of coals, general results of 10
iron ores of Northeastern Kentucky, general results of 10
soils, general remarks on 4
soils, method of 5, 40
Appendix to chemical report 155, 339
Ash analyses of Hemp and its products; clover, buckwheat, &c. . . . . 434 to 464
coal, composition of 48, 67
coal, phosphoric acid in 67
of German millet; composition of the 426, 428
of hemp and buckwheat plants, chemical examination of . . . . . 434 to 464
of Hungarian grass; composition of 425, 429
percentage of coals as compared with their specific gravity . 24, 105, 137, 157
Ashland Furnace, Boyd county, coal used at 166
pig iron, analysis of 25, 26
Band iron ore, black, from Jackson county; composition of 399, 400, 437
Barata sulphate in Owen county 314
Baregine, in Grayson Spring sulphur waters 93
Barium and Strontian Chlorides in Glen Font brine 297, 298
in Goose Creek brine 232
Barren County; composition of soils and subsoils of . . . . . 358 to 363, 434
limestones, analyses of 16
marl and nitre earth 202, 203
Bath County; composition of Ferruginous Magnesian Limestone of Chalybeate Springs in 369, 370
composition of saline waters in 371-374
composition of the Chalybeate Springs of 368, 369
composition of the mineral waters of the Olympian Springs in . . . 363, 366
facts about the mineral waters of the Olympian Springs in 358
iron ore, analysis of 16
iron ores and pig irons . . . . . 198 to 202
Sulphur waters; composition of the . . . . . 363 to 366
Bell County coals, soils, and subsoils . . . . . 203 to 215
Bellefont Furnace pig iron, analyses of 25, 217
Bessemer process; can phosphorus be removed by it? 197
Bittern water, composition and uses of, Goose Creek Salt-works 232, 233
Glen Font Salt-works 297
Bituminous Shale 264, 265, 294, 295, 316, 336
Menifee county, analysis of 140
silicious petrifaction in, Lawrence county 283

Black Band Iron Ore from Jackson county; composition of 399, 400, 437
Lawrence county 280, 281
Muhlenburg county 141, 143
"Black waxy" soil from Collins county, Texas 351, 435
Block coals of Indiana, analysis of 159
iron ore of Carter county 222
Blue Lick (lower) Spring, in Nicholas county; composition of water from . 414, 415
limestone, Cincinnati Group, of Campbell county, analysis of 42
Boiler crust and sediment, Franklin county, analysis of 73
Boone County clay 215, 216
Furnace pig iron, analysis of 57
Bored wells of Fayette county, analyses of waters of . . . . . 73 to 75
well of Franklin county, analysis of water of 78
Bourbon County magnesian limestone 155
Boyd County coals, description and analyses of . . . . . 20 to 23
iron ores, analyses of 17
soils and coals, analyses of 26, 166
Branching Chætetes, fossil, from Fayette county 383, 384
Bracken County soils and mudstone rock, analyses of 28
Breathitt County coals . . . . . 218 to 222
Breckinridge County; composition and uses of Marly shale from . . . 374, 438
red under clay, analysis of 170
Buckwheat as a fertilizer for the hemp crop 462
plants; experiments with 432
Buena Vista Furnace pig iron, analysis of 25
Buffalo Furnace pig iron, analysis of 116
Butler County; composition of coal from 375, 436
composition of Marly clay shale or Indurated clay from 375, 376, 438
iron ores, coals, and limestones, analyses of 31
Calcareous spar of blue limestone, analysis of 71
Caldwell County lead ore 34
California adobé soil, analyses of 160
Campbell County marls, shales, clays, sand, soils, analyses of 34
Cannel Coal . . . . 219, 220, 260, 263, 264, 265, 272 to 275, 291, 292, 295, 296, 315, 328
Hunnewell, Greenup county, analyses of 167
Carter County block iron ore and pig irons . . . . . 222 to 224
clays, coals, iron ores, limestones, pig irons, soils, analyses of . . . . 43 to 64, 166
Centre Furnace, in Trigg county; composition of pig iron from 421, 422, 437
Chætetes, fossil branching, from Fayette county 383, 384
Chalk rock, indurated, from Texas; composition of 425
Chalybeate mineral water, Fulton county, analysis of 81
Springs of Bath county; composition of the 368, 369
Springs, in Bath county; composition of Ferruginous Magnesian Limestone of 369, 370
waters, Grayson county, analyses of 96
Chemical Report (Third) of the soils, coals, ores, iron furnace products, clays, marls, mineral waters, rocks, &c., of Kentucky, by Robert Peter, M. D., &c., &c., Chemist to the Survey . . . . . 347 to 438
Christian County coals, mineral waters and soils . . . . . 224 to 231
Clay, carbonaceous, Muhlenburg county 150
County, Goose Creek salt waters, &c . . . . . 231 to 233

Clay, fire clay, of Muhlenburg county, analysis of 144
foot of grand chain, Illinois, analysis of 83
(potter's) from Franklin county; composition of 384, 438
from Ohio county; composition of 418, 438
German glass pot 342, 344
(Indianaite) 344, 345
ironstone from Ohio county; composition of 416, 437
ironstone, Estill county 243
Rockcastle county 321
shale, marly, or indurated clay from Butler county; composition of, 375, 376, 438
Clays . . . . . 215, 239, 242, 243, 250 to 255, 287 to 289
Campbell county, analyses of 35
comparative table, composition of 45
of Kenton county, analyses of 133
of the coal fields 15
fire clays of Carter county, analyses of 43
fire clays of Greenup county, analyses of 100
Cloverport Coal and Oil Company, their property, &c. 260, 263, 264
Clinton county marls, clay, and coal 233, 234
iron ore of Cumberland Gap 197, 198, 339, 340
Coal, Cumberland mines, Clinton county 234
fibrous, Muhlenburg county, analysis of 150, 151
in subcarboniferous limestone formation, Grayson county 88
used at Ashland Furnace, Boyd county, analysis of 166
Coalton coal (No. 7) 46, 47
Coals, Bell county . . . . . 203 to 208
block coals from Indiana, analyses of 159
Boyd county, analyses of . . . . . 20 to 23
Boyd county, relation of specific gravity to weight of ash 24
Butler county, analyses of 31, 375, 436
Carter county, analyses of 46, 166
Christian county 224, 225
Daviess county . . . . . 239 to 241
Edmonson county, analyses of 65, 66
extremes of composition of, sulphur in 191, 192
Floyd county . . . . . 248 to 250
from Illinois, analyses of 157
from Indiana, analyses of 158
from the State of Ohio, analyses of 155
from Winter's Gap, Tennessee 341
general results of analyses of 10
Grayson county, analyses of . . . . . 86 to 89, 250
Greenup county, analyses of 102, 167, 255, 256, 392, 393, 436
Hancock county . . . . . 260 to 264
Harlan county 264, 265
Hopkins county, analyses of . . . . . 130, 266 to 269
Jackson county 272, 273
Johnson county 274, 275
Kentucky, table of composition of selected samples 13
Kentucky, tables of average composition of 11

Coals, Kentucky, &c., tables of extremes of composition of 12
Lawrence county 135, 281, 282
Lee county . . . . . 283 to 285
Madison county 289, 290, 408, 436
Magoffin county 290, 292
Martin county . . . . . 292 to 294
McLean county 294, 295
Menifee county, analyses of 139, 300, 301
Morgan county 295, 296
Muhlenburg county 302, 303
Ohio, Indiana, and Illinois, average composition of 11
Ohio county, analyses of 152, 168, 305, 312
Owsley county 315, 316
Perry county . . . . . 316 to 318
Pulaski county 318, 319
relation of ash proportion to specific gravity 192, 193, 207, 208, 222
Rockcastle county 320, 321
uncombined sulphur and lime sulphate in 151
Wolfe county . . . . . 327 to 328
Coke of Coalton coal 49
used at Airdrie Furnace, Muhlenburg county 147
Collins County, Texas; "black waxy" soil from 351, 435
Texas; composition of soil from 424, 435
Composition and uses of Marly shale from Breckinridge county 374, 438
of black band iron ore from Jackson county 399, 400, 437
of clays from Ohio county 418, 438
of clay ironstone from Ohio county 416, 437
of coal from Butler county 375, 436
of coals from Greenup county 392, 393, 436
of coal from Madison county 408, 436
of indurated chalk rock from Texas 425
of limestone from Mercer county 413, 414
of limestones from Ohio county 417
of Limonite iron ore from Trigg county 420, 421, 436
of Limonite ores (iron ores) from Lyon county 407, 436
of Marly clay shale or Indurated clay from Butler county . 355, 376, 438
of material, soils, subsoils, and under-clays from Grant county . . 384 to 390, 434
of mineral water from Jessamine county . . . . . 400 to 402
of mineral water from Lincoln county 402
of mineral water (sulphur water) from Madison county 408
of mineral water from Nicholas county 414, 415
of mineral water from Warren county 422, 423
of phosphatic limestones from Fayette county . . . . . 380 to 383
of pig irons from Trigg county 421, 422, 437
of potter's clay from Franklin county 384, 438
of red bud soil from Madison county 409, 435
of Saline waters in Bath county . . . . . 371 to 374
of soils, extremes of variation in 351
of soils and subsoils of Allen county . . . . . 355 to 358, 434
of soils and subsoils of Barren county 358, 363, 434
of soils of Fayette county . . . . . 378 to 380, 434

Composition of soils from Hardin county . . . . . 393 to 397, 435
of soils from Hopkins county 398, 399, 435
of soils and subsoils from Logan county . . . . . 403 to 407, 435
of soils and under-clay from McCracken county. 410, 411, 435
of soils and under-clay of Meade county. 411, 413, 435
of soils from Oldham county 419, 420, 435
of soils from Texas. 423, 424, 435
of the Bath county Sulphur waters 363, 366
of the Chalybeate Springs of Bath county 368, 369
of the water of the "Kaiser-quelle" at Aix-la-Chapelle. 366, 367
of virgin soil and subsoil from Grayson county. 390, 391, 434, 435
of well water from Fayette county. . . . . 376 to 378
Crab Orchard Salts. 287, 288
Crown Ore, (iron) Carter county, analysis of 53
Daviess County mineral waters, soils, clays, and coals . . . . . 234 to 241
Dyestone Ore of Tennessee. 339, 340
Edmonson County iron ores, coals, and cast iron . . . . . 64 to 68, 162
iron ores and clays . . . . . 241 to 243
Estill County iron ores and pig irons . . . . . 243 to 245
Experiments with Hungarian grass, German millet, and buckwheat 245, 425
Extremes of variations in composition of soils 351
Fayette County; composition of soils of . . . . . 68 to 75, 378, 380, 434
composition of phosphatic limestones and soils from. . . 245 to 248, 380 to 383
composition of well water from 376, 378
fossil branching Chætetes from 383, 384
fossil shells from 383, 384
Ferruginous Magnesian Limestone, of Chalybeate Springs, in Bath county; composition of 369, 370
Fertilizers, mineral and atmospheric elements 9
Fibrous Coal 130, 131
Fire Clay, German glass pot. . . . . 342 to 344
of Carter county, analyses of. 43
of Greenup county, analyses of 100
of Muhlenburg county, analysis of. 144
Floyd County Coals . . . . . 248 to 250
Foxden iron ore, Carter county, analysis of 50, 51
Fossil branching Chætetes from Fayette county 383, 384
shells from Fayette county 383, 384
Franklin County; composition of potter's clay from 384, 438
marly shales, waters, &c. 75
Fulton County, soil, mineral water, clay, silicious deposits, sandstones, &c. . 80 to 83
Galena from Owen county. 313, 314
in Henry county. 129
(lead ore) from Harrison county. 397, 398
of Caldwell county, analysis of 174
German glass pot fire clay. . . . . 342 to 344
(iron) ore, Carter county, analysis of, &c.. 52
millet. . . . . 353 to 355
millet; composition of the ashes of . . . . . 426 to 428
Glairine in Grayson Springs sulphur waters. 94
Glen Font Salt Works, Meade county . . . . . 296 to 300

Goose Creek Salt Works, Clay county . . . . . 231 to 233
Grayson County coal, clay, and iron ore . . . . . 250 to 255
iron ores, marly shales, sandstone, coals, waters, and soils . . . . 83 to 100, 163
Springs mineral waters, analyses of . . . . . 89 to 97
Greenup County clays, coals, limestones, iron ores, pig irons, and soils, 100 to 118, 167
Grant County; composition of material, soils, subsoils, and under-clays from, 384 to 390, 434
Grass, Hungarian . . . . . 353 to 355
composition of the ashes of . . . . . 425 to 429
Grayson County, Texas; composition of soils from 423, 424, 435
composition of virgin soil and subsoil from 390, 391, 434, 435
Greenup County; composition of coals from 392, 393, 436
coals, pig irons, iron furnace slags, and soils . . . . . 255 to 260
Grey lime ore 107
Hancock County coals . . . . . 260 to 264
Hardin County; composition of soils from . . . . . 117 to 129, 393 to 397, 435
Hard limestone water of Fayette county for irrigation, &c. 73
Harlan County coals 264, 265
Harrison County; lead ore (galena) from 397, 398
Hematite iron ore, red, Lawrence county 137
Hemp culture, influence on soil, &c. 69
and buckwheat plants, chemical examination of the ashes of . . . . 439 to 464
culture in Kentucky 441, 442, 443, 449, 451, 456
dew-rotting and water-rotting, changes which occur in 451, 453
Henderson's process for the purification of iron . . . . . 195 to 197
Henry County galena (lead ore) and marly shale 129
metallic lead and limestone 265, 266
Hocking Valley (Ohio) coals 156
Hopkins County coals and ocherous iron ores 130
coals and soils . . . . . 266 to 272
composition of soils from 398, 399, 435
Horsley Bank iron ores, Carter county 51, 52
Hungarian Grass . . . . . 353 to 355
composition of the ashes of . . . . . 425 to 429
microscopic photographs of 428
Hunnewell Furnace pig iron . . . . . 116, 256 to 258
Indianaite of E. T. Cox 344, 345
Indiana coals, analyses of 158
Indurated chalk rock from Texas; composition of 425
clay, or marly clay shale, from Butler county; composition of . . 375, 376, 438
Illinois clay, Post Tertiary, analysis of 83
coals, analyses of 157
Iron furnace slag, Raccoon Furnace 258
Henderson's process for purification of . . . . . 195 to 197
Iron Hill, Carter county 223, 224
Iron Hills Furnace, flux limestone, analysis of 56
Furnace, pig iron, analysis of 57
Iron Ore, black band, from Jackson county; composition of 399, 400, 437
(Clay ironstone) from Ohio county; composition of 416, 437
Clinton, of Cumberland Gap 197, 198

Iron Ore, limonite, from Trigg county; composition of 420,421, 436
limonite, of Clinton Group, Bath county, analysis of 16
of Grayson county 83, 163, 254
Iron Ores, black band, Lawrence county 280, 281
carbonates 216, 217
general results of analyses of 10
(Limonite ores) from Lyon county; composition of 407, 436
Limonite of Bath county . . . . . 198 to 200
of Boyd county 17, 216, 217
of Butler county, analyses of 31
of Carter county, analyses of 49
of Edmonson county 64, 162, 241, 242
of Estill county 243, 244
of Greenup county, analyses of 106
of Kentucky, extremes of proportion of iron and phosphorus in. 193
of Lyon county 138
of Muhlenburg county, analyses of 143
ochreous, Hopkins county, analyses of 131
Iron, Pig, extremes of composition of 198
of Bath county. . . . . 200 to 202
of Greenup county. . . . . 256 to 258
of Kentucky, average composition of. 15
Irons, Pig . . . . . 198, 200 to 202, 217, 218, 256 to 258
Jackson County coals 272, 273
composition of black band iron ore from. 399, 400, 437
Jessamine County; composition of mineral water from . . . . . 400 to 402
mineral water 273, 274
Johnson County coals. 274, 275
"Kaiser-quelle" at Aix-la-Chapelle; composition of the. 366, 367
Kaolin, Indiana. 344, 345
Kenton County silicious grit, clays, marly shales, and limestones. . . . . 132 to 135
Furnace, limestone flux used at 105
Furnace, pig iron, analysis of 116
Kentucky natural resources. 190, 191
Kidney iron ore. 111, 112
Knox County ferruginous limestones and soils . . . . . 275 to 278
Lambert iron ore. 52
Laurel County soils . . . . . 278 to 280
Laurel Furnace pig iron. 257, 258
Lawrence County black band iron ores, coals, limonite ores, &c. . . . . 280 to 283
coals and iron ore. . . . . 135 to 137
Lead, metallic, Henry county 265
ore (galena) from Harrison county 397, 398
ore (galena) Royal mines, Livingston county 137
ore of Caldwell county, analysis of. 34
ore of Henry county 129
Lee County coals. 283, 284
Leitchfield marls. 250, 255
Lewis County soils. 287, 288
Lime of Fayette county (blue limestone), analysis of. 71
(quick lime), of Montgomery county. 141

Lime, use of, on soils 70, 71
Limestone (blue argillaceous), Kenton county, analysis of 134
blue, of Campbell county, analysis of 42
Ferruginous, Knox county 275, 276
Ferruginous Magnesian, of Chalybeate Springs, in Bath county; composition of. 369, 370
Lower Silurian, Henry county. 266
Kenton county, useful in agriculture. 135
magnesian, Bourbon county, analysis of 155
Muhlenburg county, used at Airdrie Furnace 144
ores, limonite ores 108, 112
ores of Carter county, analyses of 49, 50
phosphatic, of Fayette county. 198
from Mercer county; composition of. 413, 414
phosphatic, from Fayette county; composition of. . . . . 380 to 383
Limestones of Carter county, analyses of. 56
of Greenup county, analysis of 105
upper subcarboniferous oölitic and lithographic. 16
from Ohio county; composition of. 417
Limonite iron ores, Bath county. . . . . 198 to 200
iron ores, Edmonson county. 241, 242
iron ores, Estill county 243, 244
iron ore, Grayson county 254
iron ores, Lawrence county 282, 283
iron ore, Menifee county 301
iron ore, Ohio county 312, 313
ores (iron ores) from Lyon county; composition of 407, 436
iron ore from Trigg county; composition of. 420, 421, 436
Lincoln County clay and Crab Orchard Salts. 287, 288
composition of mineral water from. 402
Lithographic stone 16
Livingston County galena (lead ore) 137
Logan County; composition of soils and subsoils from. . . . . 403 to 407, 435
Lower Block iron ores. 106, 107, 109, 110, 112
Carter county, analyses of. 50, 51, 53
Lower Blue Lick Spring, in Nicholas county; composition of water from the, 414, 415
facts about the mineral waters of the 353
Lyon County; composition of Limonite ores (iron ores) from 407, 436
iron ores, &c.. . . . . 138, 161
Madison County; composition of coal from. 408, 436
clays and coals. . . . . 288 to 290
composition of mineral water (sulphur water) from 408
composition of red bud soil from. 409, 435
Magoffin County coals . . . . . 290 to 292
Main Block iron ore, Carter county, analyses of. 52, 53, 54
ore 107, 110, 111
Marl, Barren county. 202
Marls and marly shales, of Campbell county, analyses of. 34, 42
marly shales, &c., alkalies and phosphoric acid in 14, 24, 34, 75, 84
or shales of the Chester Group ("Leitchfield marls"). . . . . 250 to 255

Marly Clay, Clinton county 233
of Grayson county and their uses . . . . . 250 to 255
shale or indurated clay from Butler county; composition of . . . 375, 376, 438
Marly Shale from Breckinridge county; composition and uses of 374, 438
of Boyd county 24
of Franklin county, analysis of 75
of Grayson county, analyses of 84
of Henry county, analysis of 129
of Kenton county, analyses of 134
Martin County coals . . . . . 292 to 294
Material, soils, subsoils, and under-clays from Grant county; composition of, 384 to 390, 434
McCracken County; composition of soils and under-clay from . . . 410, 411, 435
McLean County bituminous shale and coal 294, 295
Meade County; composition of soils and under-clay of . . . . . 411 to 413, 435
Menifee County coals and bituminous shale 139
coals and iron ores 300, 301
Mercer County; composition of Limestone from 413, 414
Metallic iron (Meteoric), Rockcastle county 322
Microscopic photographs of Hungarian grass 428
Millet, German . . . . . 353 to 355
composition of the ashes of . . . . . 426 to 428
Mineral Paint, Franklin county 75
Grayson county 85
Hopkins county 131
Mineral Water from Jessamine county; composition of 400, 402
from Lincoln county; composition of 402
chalybeate, Fulton county, analysis of 81
chalybeate, Pulaski county 319
of Christian county, salt sulphur, Hopkinsville 225, 226
sulphur, Fleetwood farm, Franklin county 79
(sulphur water) from Madison county; composition of 408
from Nicholas county; composition of 414, 415
from Warren county; composition of 422, 423
sulphur, Webster county 323
Mineral Waters, chalybeate and alum, Daviess county . . . . . 234 to 236
chalybeate, Webster county 323
chalybeate, Whitley county 325
of Grayson Springs . . . . . 89 to 97
of Kentucky, general remarks on 15
of the Lower Blue Lick Springs, in Nicholas county, facts about the 353
salt sulphur, at Nicholasville, Jessamine county 273, 274
sulphur, &c., Daviess county 236, 237
of the Olympian Springs, in Bath county; composition of 363, 366
of the Olympian Springs, in Bath county; facts about the 353
Montgomery County quicklime, analysis of 141
Morgan County coals 295, 296
Mt. Savage Furnace limestone, used as a flux at 56
pig iron, analysis of 57, 223, 224
Mudstone, silicious, of Bracken county, analysis of 30
Muhlenburg County coals and soils 302, 305

Muhlenburg County iron ores, limestone, clay, pig iron, coals &c. . . . 141 to 152
Nicholas County; composition of mineral water from 414, 415
facts about the mineral waters of the Lower Blue Lick Springs in 353
Nitrates in soils 40
Nitre Earth of Barren county 202
Nitrogen, how supplied to plants 189
Nobel's apparatus for silt analysis of soils 40
Nolin Furnace (old), ore and pig iron from 162, 163
Ochre, brownish yellow, Hopkins county 131, 132
Ohio County coals and iron ores . . . . . 305 to 313
coals and soils 152, 153, 168
composition of clays from 418, 438
composition of clay ironstone from 416, 437
composition of limestones from 417
Ohio (State) coals, analyses of 155
Oldham County; composition of soils from 419, 420, 435
Olympian Springs, in Bath county; composition of the mineral waters of the, 363 to 366
facts about the mineral waters of the 353
Ore, black band iron, from Jackson county; composition of . . . 399, 400, 437
limonite (iron) from Lyon county; composition of 407, 436
Owen County galena and barata sulphate 313, 314
Owsley County coals 315, 316
Panicum Germanicum; composition of the ashes of . . . . . 425 to 429
Plants, action of, on rock materials 431, 433
buckwheat; experiments with 432
Peach Orchard coal 281, 282
Pennsylvania Furnace pig iron . . . . . 256 to 258
Perry County coals . . . . . 316 to 318
Peter, Robert, M. D., &c., chemical examination of the ashes of hemp and buckwheat plants 439, 464
Third Chemical Report of the soils, coals, ores, iron furnace products, clays, marls, mineral waters, rocks, &c., of Kentucky . . . . . 349 to 438
Sixth Chemical Report . . . . . 181 to 346
and John H. Talbutt, Fifth Chemical Report . . . . . 1 to 180
Phosphatic limestone, Fayette county . . . . . 198, 245, 380 to 383
Phosphoric Acid in coal ash 67
Phosphorus in iron, influence of, and modes of its removal . . . . . 193 to 195
in iron furnace cinder 194, 258
Pig Iron, Airdrie Furnace, Muhlenburg county 145
average composition of Kentucky 15
extremes of composition of 198
from Clinton ore 341, 342
from Trigg county; composition of 421, 422, 437
of Bath county . . . . . 200 to 202
of Boyd county, analyses of 25, 217, 218
of Carter county 223, 224
Carter county furnaces, analyses of 57
of Estill county 244, 245
of Greenup county, analyses of . . . . . 116, 256 to 258
Old Baker Furnace, Edmonson county 67

Pig Iron, Old Nolin Furnace, Edmonson county, analysis of 162
Potato Knob iron ore, Carter county 52
Potter's Clay from Franklin county; composition of 384, 438
Pulaski County coals and chalybeate water 318, 319
Raccoon Furnace, flux used at 105
slag 258
Red-bud soil from Madison county; composition of 409, 435
Red limestone (iron) ore, Carter county, analysis of 54
River Furnace pig irons 244, 245
Report (Chemical), Third, of the soils, coals, ores, iron furnace products, clays, marls, mineral waters, rocks, &c., of Kentucky, by Robert Peter, M. D., &c., &c., Chemist to the Survey . . . . . 349 to 438
Rockcastle Chalybeate Springs, Pulaski county 319, 320
county coals, clay and metallic iron . . . . . 321 to 323
Rock Material; action of plants on . . . . . 431 to 433
Rough Ore (iron), Carter county, analysis of 53, 111
Rye as a fertilizer for hemp crop 459, 460
Saline Waters in Bath county; composition of . . . . . 371 to 374
Salt Sulphur Water from Nicholas county; composition of 414, 415
Salt Water, salt, bittern, &c., Glen Font salt works . . . . . 296 to 310
Salt Works, Goose creek, Clay county . . . . . 231 to 233
Sandstone of Grayson county, analysis of 86
(soft), Fulton county, analysis of 82
Shale, bituminous, Menifee county 140
marly, in Breckinridge county; uses and composition of 374, 438
Shells, fossil, from Fayette county 383, 384
Silicious concretions, Fulton county 81
deposits of Fulton county, remarks on 82
grits, Kenton county, analyses of 132
mudstone of Bracken county, analysis of 30
Silt, analyses of soils 40
Silver in the lead ore of Caldwell county 34
Soil, adobé, of California, analysis of 160
analyses, general remarks on 4, 5
"black waxy" from Collins county, Texas 351, 435
comparative exhaustion of, by hemp, corn, wheat, and tobacco 454, 455
how to enrich it for hemp culture 460, 461
insoluble silicates of 187, 188
its fertility, as influenced by dry seasons 449
organic matters of, influence of 187
red-bud, from Madison county; composition of 409, 435
virgin, and subsoil from Grayson county; composition of, 97, 390, 391, 434, 435
Whitley county 327
Soils and subsoils of Allen county; composition of . . . . . 355 to 358, 434
and subsoils of Barren county; composition of . . . . . 358 to 363, 434
and subsoils of Logan county; composition of . . . . . 403 to 407, 435
subsoils, material, and under-clays from Grant county; composition of, 384 to 390, 434
and under-clay of Meade county; composition of . . . . . 411 to 413, 435
and under-clay from McCracken county; composition of 410, 411, 435
agricultural capabilities of, ascertained by analyses 41

Soils, analyses of silicious residue and sand of 40, 70
causes of exhaustion of, in hemp crop 456
comparative analyses of old and new 8, 41, 64
exhaustion by cropping shown by analysis. 8, 41, 64
extremes of variations in composition of. 351
&c., of Bell county. . . . . 208 to 215
of Boyd county, analyses of. 26
of Bracken county, analyses of 28
of Campbell county, analyses of. 36
of Carter county, analyses of 58
of Christian county . . . . . 226 to 231
of Daviess county . . . . . 237 to 239
of Fayette county, composition of. . . . . 68, 446 to 448, 378 to 380, 434
of Fulton, analyses of. 80
of Greenup county, analyses of 117, 259, 260
of Hardin county, analyses of. . . . . 117 to 129, 393 to 397, 435
from Hopkins county, composition of . . . . . 269 to 272, 398, 399, 435
of Kentucky, limits of variation of composition of 185
of Knox county 276, 278
of Laurel county. . . . . 278 to 280
of Lewis county. 285, 287
of Muhlenburg county 303, 304
of Ohio county, analyses of 153
from Oldham county, composition of. 419, 420, 435
from Texas, composition of 423, 424, 435
of Webster county. 324, 325
rich and poor, characteristics of 185, 186
silt, analysis of. 40
Specific gravity of coals compared with ash proportions, 24, 192, 193, 207, 208, 222
Subsoil, influence of subsoiling, trenching 186, 187, 231
soils, material and under-clays from Grant county; compositon of, 384 to 390, 434
and virgin soil of Grayson county; composition of 390, 391, 434, 435
Sulphur in Coals 191, 192, 206, 207
determination of. 14, 24
not all injurious in iron smelting 160
Sulphur Waters of Bath county; composition of the. . . . . 363 to 366
Fleetwood farm, Franklin county, analysis of. 79
Grayson county, analyses of. . . . . 89 to 96
water in Madison county, composition of. 408
from Warren county, composition of. 422, 423
Sulphur, uncombined, in coals. 151
Suwanee Furnace iron ores, analyses of. 138
Table of ash analyses of dew-rotted hemp 452
of ash analyses of the fibre of dew-rotted hemp and hemp-herds. 454
of the ash composition of buckwheat 462
of composition of clays. 180
of the ash constituents of clover and hemp. 461
of the ash constituents of hemp plants. 447
of the ash constituents of the leaves, roots, and stems of hemp. 449
of the entire ash of hemp plants 446

Table of composition of clay ironstone ores 175, 336
of composition of coals . . . . . 176 to 178, 332 to 335
composition of iron ores (limonites) 173, 174, 335, 336
of the average composition of Kentucky coals 11
of composition of limestones 172
of composition of marls, marly shales, silicious concretions, &c. 179, 338
of composition of pig irons 181, 337
of selected Kentucky coals 13
of composition of soils, &c., &c. . . . . 170 to 172, 330, 331
of the extremes in the composition of coals of Kentucky 12
Talbutt, John H., chemical assistant 1, 3
Texas; "black waxy" soil from Collins county, in 351, 435
composition of indurated chalk rock from 425
composition of soils from 423, 424, 435
Third Chemical Report of the soils, coals, ores, iron furnace products, clays, marls, mineral waters, rocks, &c., of Kentucky, by Robert Peter, M. D., &c., &c., Chemist to the Survey . . . . . 347 to 438
Trigg County; composition of limonite iron ore from 420, 421, 436
composition of pig irons from 421, 422, 437
Trigg Furnace, in Trigg county; composition of pig iron from . . . 421, 424, 437
Under-clay, red, of Breckinridge county, analysis of 30
material, soils, and subsoils of Grant county; composition of . . 384 to 390, 434
and soils from McCracken county; composition of 410, 411, 435
and soils of Meade county; composition of . . . . . 411 to 413, 485
Uses and composition of marly shale from Breckinridge county 374, 438
Variations, extremes of, in composition of soils 351
Virgin soil and subsoil of Grayson county; composition of 390, 391, 434, 435
Warren County; composition of mineral water from 422, 423
Well Water from Fayette county; composition of . . . . . 368 to 378
Water from a bored well in Fayette county; composition of . . . . . 376 to 378
mineral, from Jessamine county; composition of . . . . . 400 to 402
mineral, from Lincoln county; composition of 402
mineral (sulphur), from Madison county; composition of 408
mineral (salt sulphur), from Nicholas county; composition of 414, 415
from interior of iron ore geode, analysis of 161
influence of on the soil 186
of Grayson Springs, analyses of . . . . . 89 to 97
of Franklin county, analyses of 76
of Fayette county, analyses of . . . . . 72 to 75
Webster County mineral waters and soils 323, 324, 325
Whitley County mineral waters, bituminous shale, and soil . . . . . 325 to 327
Wolfe County coals, &c. . . . . 327 to 329
Yellow Kidney iron ore, Carter county, analysis of 54

3 2044 102 939 410